Aguilar

Sin procesar

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ABC OF VEGETABLE FARMING
A DRAFT HIGH SCHOOL TEXTBOOK

VOLUME II

A,B,C, OF VEGETABLE FARMING.

(GENERAL PRACTICES IN GROWING VEGETABLES).

By: Neville Farquharson

PART 2.

DRAFT OF ORIGINAL

"AGRICULTURE IN JAMAICA"

Collection of papers of the Office of IICA in Jamaica.

1977 - 1978

No. I - 1. Fritz Andrew Sibbles, "Basic Agricultural Information on Jamaica", Internal Document of Work, January, 1977.

No. I - 2. Yvonne Lake, "Agricultural Planning in Jamaica", June, 1977.

No. I - 3. Aston S. Wood, Ph.D. "Agricultural Education in Jamaica", September - October, 1977.

No. I - 4. Uli Locher, "The Marketing of Agricultural Produce in Jamaica", November, 1977.

No. I - 5. G. Barker, A. Wahab, L.A. Bell, "Agricultural Research in Jamaica" November, 1977.

No. I - 6. Irving Johnson, Marie Strachan , Joseph Johnson, "Land Settlement in Jamaica", December, 1977.

No. I - 7. Government of Jamaica, "Agricultural Government Policy Papers", February, 1978.

~~No. I - 8.~~ Jose Emilio Araujo, "The Communal Enterprise", February, 1978.

No. I - 9. IICA and MoAJ "Hillside Farming Technology - Intensive Short Course", Vols. I and II, March, 1978.

No. I - 10. Jose Emilio Araujo, "The Theory Behind the Community Enterprise-Seminar in Jamaica", March, 1978.

No. I - 11. Marie Strachan, "A National Programme for the Development of Hillside Farming in Jamaica", April, 1978.

No. I - 12. D.D. Henry, "Brief Overall Diagnosis of Hillside Farming in Jamaica", May, 1978.

No. I - 13. Neville Farquharson, "Production and Marketing of Yams in Allsides and Christiana", May, 1978.

No. I - 14. R.C. Harrison, E.McDonald, A.H. Wahab, "Fertility Assessment of Newly Terraced Hillside Soils using the Microplot Technique, the Allsides Case Study", May, 1978.

No. I - 15. IICA - IDB "Course in Preparation and Evaluation of Agricultural Projects", Vols. I and II, November, 1977.

No. I - 16. Neville Farquharson, "Production and Marketing of Dasheen in Allsides and Christiana", June, 1978.

1978 - 1979

II - 1 O. Arboldea-Sepulveda (IICA-CIDIA),"Agricultural Documentation and Information Network in Jamaica (Elements for a Proposal)

II - 2 Victor Quiroga,"National Agricultural Information System (NAIS - Jamaica) Project Profile, September, 1978.

II - 3. Joseph S. Johnson "A Review on Land Reform in Jamaica for the Period 1972-1978" September 1978.

II - 4. Neville Farquharson, "ABC of Vegetable Farming" A Draft High School Textbook. Volumes I, II, III and IV February 1979.

FOREWORD

IICA - Jamaica - who recognised the need - with financial assistance from the Canadian High Commission and the Royal Netherlands Embassy, spearheaded the preparation of "ABC of Vegetable Farming" - a high school textbook to teach Agriculture.

"ABC of Vegetable Farming" is a revolutionary step in Caribbean secondary education, in that it seeks to provide that much talked about agricultural textbook information which was hitherto conspicously absent.

This most important break-through and the information provided therein are in line with the philosophy of Caribbean Governments and the Jamaican Ministry of Agriculture which clearly indicates that children at primary and secondary stages of education should be exposed to agricultural education.

While no praise can be too high for IICA, the Canadian High Commission, the Royal Netherlands Embassy and Jamaica (Ministry of Agriculture) for their sterling contribution, special tribute should be paid to two members of the staff of the Ministry of Agriculture, Jamaica - Mr. Neville Farquharson who prepared the original document in 4 volumes and Garnet Malcolm who read and assisted in editing the document.

It is my wish that "ABC of Vegetable Farming" will not only find pride of place in school and home libraries, but will be used to the extent it will assist in guiding teachers to impart, and students to become eminent fellows in their fields of endeavour. For the youth to whom this textbook is dedicated, I am sure it will become a guiding influence.

Derrick Stone
Permanent Secretary
Ministry of Agriculture of Jamaica.

PROLOGUE

The office of IICA/Jamaica is extremely pleased that the proposed book titled "ABC pf Vegetable Farming" has reached this draft stage of preparation.

The fact that this activity became possible once IICA had thought of the idea was due in large measure to the financial assistance provided by the Canadian High Commission and the Royal Netherlands Embassy, to both of whom we are profoundly grateful.

There is little doubt that the proposed text-book will fill an important gap in the education of the youth of the English speaking Caribbean countries. The existing high dependence on agriculture; the low status of agriculture in most of these countries and the associated low incomes of rural dwellers, most of whom rely on agriculture for a living; the high degree of rural/urban migration and the social costs associated therewith, are factors which make it necessary to take early steps to inculcate into our youth knowledge concerning agriculture. This book is a contribution to that effort.

While expressing my pleasure with the outcome of this venture and the catalytic role which IICA/Jamaica has been able to play. I also record my fervent hope that this book will be only the first in a series of such publications.

In the above context I must also express our pride in having been able to work with Mr. Neville Farquharson of the Ministry of Agriculture, Jamaica on this activity.

This draft preparation is being presented to a number of key personnel in the English speaking member countries of the Caribbean for suggestions for modification where appropriate. These suggestions will then be made available to IICA's Central Office in San Jose for the attention of Carlos Molestina, Director of Public Information and Publication. The book in final form is expected to be the result of action to be taken by IICA's Headquarters at San Jose.

Percy Aitken-Soux PhD.
Director, IICA Office, Jamaica.

TABLE

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(PART. 2)

Commonly used British Measurements.

Length	Symbols	Volumes	Symbols
12 inches = 1 foot	12 in = 1 ft. or 12 " = 1'	2 gills = 1 pint 2 pints = 1 quart	2 gills = 1 pt. 2 pt = 1 qrt.
3 feet = 1 yard	3 ft. = 1 yd.	8 pints = 1 gallon	8 pts = 1 gall.
66 feet = 1 chain	66 ft = 1 chn.	4 quarts= 1 gallon	4qrt. = 1 gall.
22 yards = 1 chain	22 yds= 1 chn	8 gallons = 1 bushel	
80 chains = 1 mile	80 chn.= 1 mile		

Area	
144 sq. inches = 1 sq. foot	144 sq. ins. = 1 sq. ft.
9 sq. feet = 1 sq. yard	9 sq. ft. = 1 sq. yd.
4356 sq ft. = 1 sq. chain	4356 sq. ft = 1 sq. chn.
484 sq. yd. = 1 sq. chain	484 sq. yd. = 1 sq. chn.
10 sq. chain = 1 acre	10 sq. chn = 1 ac.

Weight	
16 ounces = 1 pound	16 ozs = 1 lb.
100 pounds = 1 short hundred wt.	100 lb = 1 hb.
112 pounds = 1 long hundred wt.	112 lbs = 1 cwt.
20 hb = 2000 lbs = 1 s. ton.	20 hbs = 1 s. ton.

Commonly Used Metric Measurements

Length	Symbols	Volumes	Symbols.
10 millimetre = 1 centimetre	10 mm = 1 cm	1000 millilitre = 1 litre	1000 ml = 1 l
100 centimetre = 1 metre	100 cm = 1 m.	1000 litre = 1 kilolitre (or stere)	1000 l = 1 kl.
1000 metre = 1 kilometre	1000m = 1 km		

Area	
100 sq. metre = 1 Are	
10,000 sq. metre = 1 hectare.	10000sq. m = 1 ha
Weights	
1000 milligram = 1 gram	1000 mg = 1 gm.
1000 grams = 1 kilogram	1000 gm = 1 kg.
1000 kilogram = 1 metric tonne	1000 kg = 1 tonne

CONVERTING BRITISH MEASUREMENTS TO METRIC.

To Change		To		Multiply By.
Length				
Inches	(ins)	Centimetres	(cm)	2.5
Feet	(ft)	Centimemetres	(cm)	30
Feet	(ft)	Metres	(m)	0.3
Yards	(yd)	Metres	(m)	0.9 (approx. 1.0)*
Chain	(chn)	Metres	(m)	19.8 (approx 20)*
Milc	(ml)	Kilometre	(km)	1.7
Area				
Square feet	(sq.ft)	Square Metre	(sq.m)	0.1
Square yard	(sq.yd)	Square Metre	(sq.m)	0.8
Square chain	(sq.chn)	Square metre	(sq.m)	400*
Acre	(ac.)	Hectare	(ha)	0.4 (or 2/5)

* Note that these approx. figures will be used throughout the book for easy conversion except where an exact conversion is absolutely necessary.

To Change		To		Multiply by	
Weight					
Ounces	(ozs.)	Grams	(gm)	28	(approx 30)*
Pounds	(lbs)	Kilograms	(kg)	0.45	
Short ton	(2000 lbs)	Kilograms	(kg)	900	
Short ton	(s.ton)	Metric tons	(Tonnes)	1.1	
Volume					
Teaspoons		Milli-litres	(ml)	5	
Tablespoons		Milli-litres	(ml)	15	
Fluid ounces		Millilitres	(ml)	30	
Pints	(pts)	Litres	(l)	0.47	(approx 0.5)*
Quarts	(qrts)	Litres	(l)	0.95	(approx 1.0)*
Gallons	(galls)	Litres		3.8	
Temperature					
Forenheit (^{o}F)		Centigrade	(^{o}C	(^{o}F - 32) x 0.56	
Weight / Area					
Tons per Acre		Tonne per hectare		2.25	
Pounds per Acre		Kilograms per Hectare		1.1	(approx.1.0)*
Pounds per sq. chn.		Kilogram per Hectare		11.25	
Pounds per sq. chn.		Kilo per 400 sq. metre		0.45	(approx. 0.5)*

* The approx. Figures make the conversion of weight per unit area very simple and practicable. For example to convert lbs per sq. chn to kg. per 400 sq. m. (divide by 2) or 1/2 the weight in lbs is the approx. kg. per 400 sq. m. Similarly, lbs per acre is approx. the same weight in kg. per. ha.

Section 3 PLANNING THE VEGETABLE FARM.

Chapter 7.

In planning the vegetable farm, the first thing that must be considered, is the type of farm and its purpose. It may be one of the following:-

1.	One man farm	Operated by farmers and workers mainly for commercial purposes
2.	Co-op farms	
3.	State farms	
4.	School farms	Operated by students and agriculturalists for demonstration and experimental purposes.
5.	Experimental farms	

Planning is a vital part of vegetable production. It is important not only for a new farm, but as long as one is growing vegetables. Plans always have to be made to improve production and marketing of crops. In this chapter, we will deal briefly with some of the things farmers should do in starting a farm.

Most farmers in the tropics do farming to supply food for the family and to make money to purchase what he needs, but does not produce. In other words, farming is done both for subsistence and commercial purposes. For his domestic need, the farmer simply has to plant a variety of crops that his family need. But for the commercial or business side, the farmer will have to study a number of factors that will affect his business, he has to make assessments. Why?

1. <u>To get some idea of cost and returns.</u>

   Before the vegetable farmer starts his business, he should have a fair idea of certain things that he needs to do, what they are likely to cost and what will be his likely returns after such operations, He must also have some ideas of some of the general problems in vegetable growing in the area.

2. <u>To decide whether or not to grow vegetables</u>

   After knowing what to expect, the intended vegetable farmer can decide whether or not he should grow vegetables. Suppose for instance his land slopes to such an extent that to avoid serious erosion, he would have to use terraces. And suppose he knows that this is an expensive operation and he could not find the money required, then before starting he might think of something other than vegetables. Otherwise, he will buy expensive equipment and spend a lot of money only to find later that they cannot be efficiently used, then it will be too late.

What to Assess.

Here are some of the main things to be carefully checked out in planning to grow vegetables.

Market for vegetable.
Knowledge of growing and marketing vegetables.
Climate of the area.
Feature of the land he plans to use.
How available are key inputs.
Money needed and how it can be got.

The farmer will have to assess these and see if and how he will try to solve the problems faced in each case.

A. MARKET

1. How am I going to sell my crops is the first question the intended farmer should ask himself. This is so important because the market is one thing that the individual vegetable farmer in the tropical regions has almost no control over. He can do something to make other factors more suitable but not market.

Here we should think of the market in terms of demand and where this demand is located. The farmer at all times has to find out the crops that are in greater demand and sell at the best price at different times in the markets that he decides to sell. This check on demand, supply and prices at different times is a regular exercise in any business in a capitalist country.

2. Location of the market is important in that the further away the market is, the higher the transportation cost for the vegetables are likely to be.

In addition, the further away the market, other things like need for packing in special containers might be necessary. These might also increase cost of producing the crop. Also, where the farmer does not have his own transport, it is usually easier to get his produce to the nearer market.

B. THE TYPE OF MARKETING that the farmer does is usually the one which is most profitable and convenient to him. He may choose to sell higglers (small traders) who visit his farm and buys his produce. These traders will take the produce to sell in the town areas. Sometimes the farmer himself or some relative takes the produce to market Whichever way, the produce is sold on the national or domestic market. He may choose to sell to big private or government companies distributors while they may also sell some produce on the foreign or export market.

Most often farmers have to sell some of the produce to higglers and the surplus to the bigger traders. Sometimes, the farmer can sell to the companies by a contract. In this, the company agrees to buy a certain quantity of one or more crops at a certain price. This agreement is made before the crop comes in and ensures a market to the farmer and supply to the company when the crop is ready. Where a farmer can sell by contract at a good price, this usually works best.

KNOWLEDGE - How much do I know?

The individual who would like to grow vegetables but does not know how to grow them, must learn. If he has no knowledge, he will have to get some. If he has some knowledge he will have to get some more. There is no way of getting around this. Growing vegetables without adequate knowledge might have the same effect as growing without adequate market. It spells loss to the farmer.

What type of knowledge?

1. How to grow vegetables- The farmer should know how to grow each crop. Different crops need different treatments in their production e.g. different diseases and insects attack them. There is the need for different controls or different types and quantities of fertilizers for maximum yields.

2. Economics in vegetable growing - The farmer should have a knowledge of business and ways and means of increasing his returns from his farm. A farmer knowing how to grow the vegetables but not knowing how to make money out of growing them, might be in very low waters.

Where to get knowledge

(1) Try to read book and booklets - The vegetable grower should try to get one or two simple standard books and as many booklets as possible and as fast as they become available.

(2) Government and private agricultural agencies - These agencies can help the vegetable grower with direct advice , demonstrations on his farm and providing regular supply of booklets. In most tropical countries, the government has agricultural instructors working in different areas to give advice to farmers.

(3) Other vegetable growers - Before the vegetable grower establishes his farm and after it starts operation, he must always keep in contact with the other farmers and particularly vegetable growers in the area. They should discuss their problems and visit each others farm as individual but more suitable in their organisations.

(4) Experience in growing vegetables - Finally, the vegetable grower will learn the most through working on his farm. Most of what he learns, he will not even realise, but then he will gain the bulk of what will be in his head and learn how to use it with his hands.

The knowledge gained should also be shared with other vegetable growers. It can be shared through books or booklets, through their government agencies and with individual farmers or their organization. Note that both farmers and students can also write books and booklets for other growers to read. These might not be big books, but can provide valuable information.

CLIMATE - Features of the area in different seasons

The farmer has to be always aware of the temperature, rainfall, windiness and humidity at different times of the year in the area that his farm is located.

1. What is the temperature like?

In most tropical countries, the temperature is between 60^{o}F (16^{o}C) in the cooler months and 90^{o}F (32^{o}C) in the hotter months. Most vegetables can grow well in this range although some do better in cooler seasons and others prefer the warmer seasons.

But temperature not only determines the crops that will do best in the area at different seasons of the year, it also affect the rate of evaporation. In the warmer climate, water will evaporate from the soil more rapidly than in the cooler climate. The farmer, if he plans to grow vegetables in the hotter months, or in hotter areas, he will have to do some irrigation. The farmer should make plans for this.

The elevation, or how high the farm is above sea level, also affects temperature and evaporation. The higher the area, the lower the temperature and the rate of evaporation compared to the lowland areas in the same region at the same time of the year.

The temperature of the area in different seasons and the rainfall that goes with it, will affect the amount of irrigation and water control measures, hence costs and returns to the farmer.

2. How does rain fall?

Before starting a farm, in an area, one should try to find out the amount of rain that falls in the area as well as how this amount is distributed throughout the year.

The total rainfall helps to determine first of all whether or not the farmer can grow his vegetable from rainfall only. We should remember that vegetables generally require a considerable amount of water compared to other crops. Secondly, the rain fall might be such that natually it will create serious problems (e.g. flooding, erosion) if adequate measures are not used.

Although the total rainfall for the year might be adequate, because of the fact that most of the rain falls in 5 to 6 months of the year with the other 6 months relatively dry, irrigation has to be applied. This will increase both initial and maintenance costs since irrigation and water conservation measures like mulching will have to be used. Periods of heavy rainfall will require drainage and soil conservation measures.

3. How is wind important?

The wind can affect the farmer on the plains or hilly areas in 2 main ways. Firstly, wind can do extensive damage to crops. This is a fact known by already established growers especially near to the sea. The wind does considerable damage to tall plants like tomato or corn especially when it is accompanied by rain.

Wind-breaks have to be used to check this damage. This might increase the farmers cost of producing his crop. Trees to provide lumber and permanent crops whose fruits cannot be easily blown off by the wind, can also be planted as wind-breakers.

The wind like elevation can affect evaporation rate and increase the need both for irrigation and water conservation measures. We should also note, that the higher the farm is located, the more windy it is likely to be.

4. What is humidity like?

How humid (damp) the atmosphere of the area is, also is important, but not as important as say rainfall. The cooler the area and the more the rainfall, the more humid the climate will be. The more humid his area, the more problems in controlling diseases.

LAND - How much land can I start with?

The amount of money that the farmer has available to him will determine how much land he can start his business with. If he can get the money that he would need for the amount of land he has in mind, then his only problem is to find the required amount of suitable land. If the land is available but the money is limited, he merely has to buy the amount of land for the size farm that the money could finance. Later he might expand.

Where is the land located?

The farmer has to think about the community or district in which he is planning to farm. Then, he has to look at the location of the land in the district. This is very important since transportation to and from the farm will always be needed. The location of the farm will therefore, affect how easy and at what cost the farmer can move supplies to the farm and his produce to market.

Distance from roads, water supply for irrigation, farm supplies and market will all affect the farmer. The location of the land to be used for the farm should be chosen with these in mind.

What is the land like?

It is important in assessing, to think not only of the location and the amount of land that is to be bought, but also the nature of this land. These factors will determine both likely cost and likely returns. Among the features of the land which should be considered are:-

1. Slope - the greater the slope, the more difficult for growing vegetables. Land preparation and controlling erosion are likely to be more difficult and costly as the slope increases. Also as slope increase it becomes more difficult to use most form of equipments for land preparation, irrigation etc.

2. Stoniness - where the land is stony, the farmer will also have more problems than where stones are small and few. Land preparation, planting and weeding are likely to be more difficult and more costly, the more stones are found on the land.

3. Soil type and depth - deep loamy soils are usually best for growing vegetables. The depth and texture affects the amount of water and nutrients the soil can hold. The features will help to determine how much drainage, irrigation, mulching, fertilizing and manuring will have to be done.

MONEY - How much money do I need?

The farmer should have a good idea of how much money he will need to start his farm and produce at least his first crop.

Production costs fall under 2 main headings:-

1. Initial cost - This is the cost of initiating the operation i.e. the amount of money needed to start the business. Initial cost on the vegetable farm are usually for the purchase of:-
    - land on which farm will be located

- machinery and equipment needed in operation of farm
- buildings which might or might not be necessary for storage of equipment and general farm supplies.(Keep them somewhere around the home if near to the farm. This will reduce the need for buildings and reduce initial cost).

2. Recurrent or maintenance cost

This is the cost of maintaining the farm after it has started operation. These include:-

- labour costs which is usually payment to people working on the farm.

  The vegetable farmer should include the cost of his labour and any member of his family working on the farm. The number of people and the estimated number of days per week they are expected to work, can be used here.

- direct supply costs which includes things used throughout crop like seeds, fertilizers, fuel for machinery.

- replacement costs which is mainly money spent to replace machinery and other equipment like spray pans and tools. Items regularly used, although replaced are put on cost of direct supplies and not replacements.

- transport costs usually include spending on transportation of supplies to the farm and the produce from the farm to the market.

- other costs which do not fall under one of the categories mentioned above.

Before starting, the potential farmer should make an estimate of what each item will cost. Again, agricultural instructors and other experienced vegetable farmers can be very helpful. It is best for these costs to be calculated with allowances to compensate for increases, which will take place by the time the items are to be purchased. If this is not done, the farmer will find that the costs of the items will be greater than his estimate and he will be short of money.

How much money do I have?

The prospective grower will need sufficient money to cover his initial and maintenance costs for at least his first crop of vegetables. Then after looking at these likely figures, he must find out if he has more but not less money. If he does not have enough, he will need loans.

How much can I get?

In some tropical countries, the farmer can get loans from private banks or from government. This is usually limited, he should try to get as much as is necessary to make up what he has to the required amount for at least his first crop. He should also bear in mind that the money will have to be paid back with interest.

When the amount he requires is not available, he has to consider about reducing the size of the operation he had planned to start with. This can be done either by cutting planned initial costs (e.g. buying less land or machinery) or maintenance costs (e.g. start to work a smaller area and use less labour).

He might have to change the initial nature i.e. the way he starts his farm. For example, overhead irrigation is usually more efficient than flood irrigation in vegetable production. But if money is limited and both methods are possible, he could start with flood irrigation which is much less expensive.

Another Way to Start

In this method the farmer builds his farm on a step by step basis. This is the way most tropical growers start their business and considering lack of money, limited knowledge and poor lands, it has worked very well. Students particularly should try to study this method of starting the farm and see how it can be improved for more modern and scientific production later

(1) Land - the farmer acquires the land first. He usually gets land that might not be most suitable, but he can afford to buy, rent or lease.

(2) Money - this might come from 2 sources viz:-

   (a) small loan from government schemes or from a co-operative bank or from another person.

   (b) Savings of the farmers family. It is sometimes enough for the first crop.

(3) Equipment - The farmer gets his equipment piece by piece. For the first crop, enough small equipment is got to start the operation. A part of the land might be used, depending on the amount of money. But larger equipment will be got as the business progress. Hiring equipment will be helpful here. For example, in land preparation, the new grower might pay another farmer to prepare the land.

(4) Knowledge - This might be acquired during the course of getting land and money i.e. a knowledge of those business in vegetable growing as well as a knowledge of how to grow the crops.

The farmer also assesses his needs as he goes along, but concentrates on his immediate needs or what he needs in the near future. The farm develops (i.e. more equipment etc.) with successive crops. The profits from the precious crops is put back into the business.

Section 4. CULTIVATION PRACTICES

This section deals with the general tasks that the vegetable grower will have to do to grow his crops. Because of the difference in growing habit of the crops, different climate, soil and other conditions under which vegetables are cultivated, not all the practices will be used in growing each crop. But those dealt with in this section are the ones generally used for growing most crops.

The cultivation practices are dealt with in almost the same order in which they would be applied on a farm. But this has to be flexible, since under certain conditions the order of doing the tasks is different while sometimes 2 or 3 practices are done together.

The practices will be dealt with under the following 10 headings:-

1. Selecting crops and varieties
2. Testing soil and correcting pH
3. Applying manures and fertilizers
4. Preparing land
5. Buying seeds and planting
6. Irrigation and drainage
7. Mulching and inter-tillage
8. Controlling pests, diseases and weeds
9. Reaping and marketing
10. Keeping notes and records.

Chapter 8. SELECTING CROPS AND VARIETIES

A. SELECTING CROPS

Importance of selecting crops.

A vegetable grower who decides to grow a number of crops should consider certain factors before choosing these crops. This is particularly important to the farmer, since for him, vegetable production is primarily a business, he depends on it for a living. To get good yields and good returns from the farm, one of the first steps must be to select the crops which stand a good chance of doing well where the farm is located.

What to consider in selecting crops.

1. Market- The vegetable grower must have some definite knowledge of the products that will sell. He must know whether tomato will give better returns than cucumber or whether the tomato will sell at all. In most cases, the grower will find that market is available for a number of crops, but the amount of land, labour and money available to him might not be enough to grow all these crops. He have to consider other factors to select from the group, the number of crops he intends to grow. For example, market might be available for beans, cucumber, lettuce, okra, tomato and watermellon, but according to the amount of land the grower has, it will be more economical to grow three crops. He will therefore have to consider other factors to decide which three he should grow.

2. Seasonal requirement of crops - The vegetable grower should always select the crops most suited to the seasonal conditions (temperature, rainfall, humidity and day length) of the area at the time when it is to be grown. The selling price of a crop might enable it to give good returns. However, because of regular rainfall and damp atmosphere in an area, it cannot stand up to the disease and other problems encouraged by these conditions. Temperature and daylength might cause poor production at the time when the crop would be grown.

Other factors like the nutrient requirement of the crop and the soil on which it is grown is not as serious. Application of lime, manures can correct this situation, but if the crop is not suited to the clima it might be difficult to do anything to correct this. Trying to grow the crop in a special pattern adjusted to the climate might be helpful. (See seasonal growing). But the vegetable farmer should choose the crops that are suited to the area and can be economically grown there in that season.

Example: Cabbage is a cool season crop and will grow well in temperature range of $60^{\circ}F$ to $75^{\circ}F$. (or 16° to $24^{\circ}C$) Cucumber is a warm season crop which gives best yields between $60^{\circ}F$ to $80^{\circ}F$. (or 16 to $27^{\circ}C$)

Note that the bulk of cool season crops are those in which the vegetative part - root, stem leaves and buds are eaten. The bulk of the warm season crops are those in which the fruits and seeds are eaten. There are a few exceptions in each group.

3. Crop duration - A farmer must also think about the duration of the cro i.e. length of time from planting to final reaping. For what he will find is that although the total profit from a crop of okra might be greater than that from a crop of string beans, it might be better to grow beans than okra - Why?

Example: Let us say that a crop of okra gives a profit of $30 / sq. chn. ($30 / 400 sq. m.) and the crop is of 5 months duration, and a crop of beans give a profit of $25 / sq. chn. and the crop is of 3 months duration. Let us see what happens in a year.

For Okra		For beans	
No. of crops reaped	= 2	No. of crops reaped	= 3
Profit per crop	=$30	Profit per crop	= $25
Total profit for year	=$30x20	Total profit for year	= $75
	=$60		

Should the farmer grow okra or beans?

In cases where there is a difference of a lesser period, the shorter crop might still be more profitable as total expenses is reduced. This is due mainly to less labour usually required for growing shorter duration crops.

4. **Labour requirement** - The next consideration should be the labour (time and level of skill) required to grow the crop. Tomato for example is a crop that usually gets a better price than watermellon on the market. Its yield per acre could make its total sales higher or than mellon. But according to the amount of labour and the level of skill required for instance to transplant the crop, then the total expenses might be higher than for the mellon. The duration of a crop also affects the amount of labour required to grow it and generally shorter duration crops, require less labour than crops of longer duration. The vegetable grower should select crops that can be grown economically with a lower labour requirement.

5. **Farmers preference** - This condition is listed last, because this is the place that it should take among the factors to be considered. The farmer should try to produce the crops that he prefers to grow, when his preference and the economic interest of the business go together.

After the farmer has selected his crops, his next step would be to select the varieties of the crops he intends to grow.

B. SELECTING VARIETIES

Importance of selecting varieties

The importance of selecting varieties is similar in most ways to that of selecting crops. Because, the farmer should make sure that the variety of each crop that he grows is suited to his business. First he should be familiar with the more widely grown varieties in his area.

(8:2) Here is a list of some crops and the more commonly grown varieties of each

CROP	VARIETIES
Beans (kidney	Bountiful, Contender, Extender, Kentucky wonder
Beans (lima)	Butter-green, Fordhook 242, Nemagreen, Thaxter.
(soya)	Hardee, Improved Pelican, Lee, Seminole.
Beet	Detroit dark red, Early wonder, Flat Egyption, Red-pack.
Brocolli	Costal, Grande, Primo (hybrid), Propaygens
Brussel spout	Jade Cross (hybrid), Long Island improved.
Cabbage	Copenbagen market, Early Jersey, Flat Dutch, Globe (vars.)*
" (chinese)	Michili, Pak - choi, Wong Bok, Chiefoo
Calaloo (amaranth)	Native
Carrot	Danvers 1/2 - long, Imperator, Nantes, Chantenay
Caulifiour	Early Patna Early Snowball, Early Market
Celery	Golden self-branching, Giant Pascal, Utah 52-70
Chard (swiss)	Large ribbed, Lucellus, Ford hook Giant
Cho-cho (chayote)	White, Cream varieties
Corn (field)	Ja. selected yellow (JSY), Pioneer x 304, x 306
" (sweet)	Golden Beauty, Southern Cross, USDA - 34

* "Vars". abbreviation for varieties, means that more than one variety or cultivars bear this name, with letters and or number to distinguish them.

Crop (contd)	Varieties
Collard	Georgia, Green Glaze, Vates
Cucumber	Ashley, Palmeto, Polemer, Straight - 8, Wisconsin SMR (vars.)
Endive	Florida deep heart, Salad king, Green curled.
Escellion	Evergreen bunching, White lisbon,
Garden-egg	Black beauty, Florida Market, Long Purple.
Kale	Broadflat curl Dwaf Sibrian
Kohl-rabi	Early white vienna, Early purple vienna.
Leek	Droodflat, Carentan, Large American, Mussel-burgh.
Lettuce	Ice-burg , Mignomette, Minetto, Great Lakes (vars.)
Muskmellon	Edisto, Gulf-stream, Hales best, Smiths Perfect.
Mustard	Green wave, Southern Giant curled, Tender green
Okra	Clemson Spineless, Emerald green, White velvet.
Onion	Chrystal wax, Granex 33 (hybrid), Texas Grano.
Parsley	Dark Green Italian, Moss curled, Plain.
Parsnip	Harris Model, Hollow crown
Pea (cow)	Black-eye, Cream-body Yard-long.
" (garden)	Little marvel, Telephone
" (sugar)	Melting sugar, Rando.
" (pigeon)	Bicolor, Flavus, Khaki
Peanut	African Giant, Kano.
Pepper (sweet)	California wonder, Cubanella, Jade, Yolo wonder (vars.)
" (hot)	Casabella, Long Red Cayenne.
Potato (irish)	Red Pontiac, Sebago
" (sweet)	Flagall
Pumpkin	
Radish	Champion, Cherry Belle, Early Scarlet Globe.
Rutabaga	American Purple top.
Spinach	Bloomsdale, Long-standing, Dark-green.
Squash	Butter-nut, Caserta, Cozella, Zucchini.
Tomato	Manalucie, Manapal, Ox-heart, Roma.
Turnip	Purple top-White globe, Seven top, White flat.
Watermellon	Blackstone, Congo, Charleston Gray, Sugar baby.

What to consider in selecting varieties?

1. Market - Consumers do not choose between varieties of a crop as much as they choose between crops themselves. i.e. a housewife in market is not as keen on whether she buys BarlyJersey or Drum-head cabbage as she makes sure that if she wants cabbage she buys cabbage and not lettuce. But the fact that consumers choose between varieties makes it important that the farmer grows the varieties in demand.

There are 3 main factors that the consumer looks at viz:-

(a) Appearance of produce

(b) Quality of produce i.e. firmness and taste

(c) Price of the produce.

Appearance - The same factors the consumer will look at are the same ones the vegetable grower should also consider. If the housewife prefers Ox-heart tomato to Manaluce because of the shape and general appearance of the fruit, then grow Ox-heart. This is a pity as the consumer by looking on the appearance of the product, sometimes buy varieties that have lower nutritional value. But it is the reality that in most tropical countries the farmer has to grow a variety even if it sells more than another on the way it looks

Quality - The quality of the variety produced is very important as in most cases, people will not buy produce if it is not high quality. The fruit in addition to being attractive, must be firm with good taste. No matter how much a housewife prefer Oxheart over Manalucie if she touches the oxheart fruit and it feels like porridge while the Manalucie is firm, then she will buy the Manalucie instead.

Price - The price of the produce is ~~a~~ factor that has to be considered seriously by the grower. Sometimes a variety sells at a higher price than another, because that variety gives a lower yield than another one. The farmer will have to look not only on price but on his total sales. For example, Sugarbaby watermellon because it is sweeter and of lower yield than say Charleston Gray will usually sell at a higher price. But should a farmer decide from this to grow Sugarbaby - No! First he must consider whether the total sales for Charleston Gray per sq. chn. will not be greater than that from Sugar baby.

2. The yield of a variety is very important and the potential yield of different varieties must be looked at in determining which variety to grow.

<u>Example</u>: Suppose the yield from Sugar-baby is 6 hbs / sq chn.* and sells at 8¢ per lb and the yield from Charleston Gray is 8 hbs / sq. chn. and sells at 7¢ per lb and both varieties have the same total cost (or expenses) ($26).

Total Profit (TP) = Total Sales (TS) - Total Costs (TC)

For Sugar-baby					For Charleston Gray			
Total sales	=	600 x 8¢	=	$48	Sales	800 x 7¢	=	$56.00
" Costs	=	$26	=	$26	Costs		=	$26

Now should he grow the variety that sells at the highest price per lb ?

3. Seasonal requirement of each variety

In selecting varieties, the farmer should also think of the seasonal requirements of the varieties i.e. how well the variety is adapted to the local climate conditions. He should choose varieties adapted to the conditions of the area. eg. If the area is humid and encourages diseases, disease-resistant varieties should be planted eg. Polmar DMR (resistant to downey mildew) might be a better variety of cucumber to grow than say Poinsett.

How well is the variety adapted to other seasonal conditions (temperature, day length) of the area. For example some varieties of corn although grown in tropical regions is not adapted to day length in the area. Only the varieties suited to the seasonal conditions of the area should be planted. The difference in the performance of the two varieties of corn shown below will illustrate this point.

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* 1 hb per sq. chn = 100 lbs per sq. chn or approx. 50 kilograms per 400 sq. metre.

(8:3) (a) Butterfinger corn with poorly developed ear (htapp. 1m or 4

(b) X - 306 corn with well ears (ht app. 6 ft or 1 m.)

(4) Duration of each variety - The vegetable grower should always try to grow varieties of shorter duration. This should be done considering the market prices of a variety. However, the difference in duration of the varieties of a crop is important in the same way that duration of different crops is important. The difference in duration of varieties is almost as great as for crops. For example Golden acre cabbage takes about 9 weeks from transplanting to reaping, while Late flat dutch takes about 14 weeks.

(5) Labour requirement. The growth habit of each variety including its duration, would affect its labour requirement. For instance, a bush variety of beans (eg. Contender) and a pole variety (eg Romano) have different labour requirements. One reason is that Contender would be ready for first reaping in about 7 weeks with about 2 weeks reaping necessary. Romano on the other hand would be ready for first reaping in about 10 weeks and will take a longer period for final reaping. Now the difference in duration of both varieties makes it necessary to use more labour on Romano than on Contender.

In addition, because Romano is a pole variety (grows to 5-6 ft tall or app. 1.5 - 2 m.) and Contender is a bush variety (grows to 12"-15" tall or app. 30 - 40 cm) in most cases, Romano has to be grown on stakes. This difference in the growth habit or the way the plant grows, causes the difference in labour cost. The vegetable farmer should try to select varieties that can be economically grown with a lower labour requirement.

(6) Farmers preference - Vegetable growers are not usually as choosy between varieties as between crops. In selecting varieties, the grower should plant varieties that he likes to grow only when these are also profitable to the business.

(8:4) (a) A bush variety of beans.

(b) A pole variety grown on stakes.

Chapter 9. TESTING SOIL AND CORRECTING pH.

A. TESTING THE SOIL

Importance of testing the soil.

Testing the soil on which crops are to be grown is a very important feature of vegetable growing. It helps the vegetable grower to know what the condition of his soil is at the time that the test is done. He is then in a better position to know what should be done to improve the soil to make it suitable for the crops he wishes to grow.

Method of testing soil.

There are 2 commonly used methods of testing soils. These are:-

- Simple field experiments
- Chemical tests of soil samples or plant tissue.

Simple field experiments.

This method of testing soil is not a very difficult one, but one that takes some amount of knowledge to set up the experiments and interpret the results. It can be tackled suitably by the student, but might be more difficult for the farmer.

(9:1) Plots of vegetables in simple field experiments

Small plots of the same sizes are given different treatments e.g. different grades of fertilizers and different quantities of one or more grades. If the soil is suspected of being too acid, different quantities of lime would also be added. The production from the treatments would be observed to see which treatment gives the highest yields with the least extra expenses. Field trials are sometimes used even after chemical tests and can be done while growing a crop for market. Such experiments or trials are dealt with in section 6.

Field test to determine soil texture.

By general observation of the speed at which water is absorbed after rainfall or irrigation, the vegetable grower could get some idea of his soil texture . The water would generally soak through sandy soils more quickly than clayey soils. The feel of a soil, can also help to determine its texture. Here is a useful guide.

(9:2)

Soil Texture	Internal Drainage	Feel of soil	
		(Dry)	(Wet)
Sandy soils	Very rapid	Loose single grains, will flow through fingers	Hardly stick together when squeezed
Silt soils	Rapid to fairly rapid	Lumps easily break up into powder	Can be squeezed into ball which crumples easily
Sandy loams	Fairly rapid to moderate	Loose coarse particles flow through fingers	Can be squeezed into ball, but will not hold shape
Clay loams	moderate to fairly slow	Small lumps that will easily crumple	Sticky and can be squeezed into ball
Clay soils	Slow to very slow	Has tough clods which will not break easily	Very sticky and can be squeezed easily into ball

Nutrients.

Check the soil survey map of the area. It will give the levels of each element in the different soil types. If the grower has identified his soil type, then he should see the general recommendations for different crops on soils of this type.

Another way is to grow the crops that will be selected using a NPK/10-10-10 fertilizer. Observe the crops and try to identify the elements in short supply (deficiency). The vegetable grower who knows the elements that are deficient can apply the grade fertilizer required to correct this deficiency. To determine the rate of fertilizer to be applied on various crops, a more elaborate trial will be necessary.

Field test to determine soil pH.

To get some knowledge of the pH level of the soil, the vegetable grower should get a small soil pH kit. This is a piece of equipment that can be used by both the student of vegetable growing and the farmer. It is simple to use and fairly cheap.

Certain dyes or indicators are added to the small soil sample. The dye changes the colour of the soil according to its pH. The colour of the soil mixture is compared to a chart and the pH of the soil is determined. Fairly accurate tests can be made in the field and the results known immediately. Trials can be made to determine the requirements for correcting soil acidity, but the vegetable grower could save himself a lot of trouble, by getting one of these kits .

Chemical tests.

Chemical tests are the quickest and most accurate methods of testing soil. There are two types of chemical tests. In the first, a collection of parts of plants (usually leaves) are sent to the laboratory where those plant parts are analysed.

In the second type, an auger or a spade is used to take up small amounts of soil from 3 to 5 different parts of the area to be tested (soil samples). Samples are usually made from the top 30 inches (75 cm) with a sample in each 6 inch (15 cm) zone.

The samples are then sent to the laboratory where they are analysed. The results and recommendations for growing different types of crops are sent back to the grower.

These recommendations are merely guides indicating what treatments are likely to give good results. The vegetable grower will have to test them to see if they work.

The greatest draw-back with chemical tests is that they are carried out by government agencies or private firms and not available to most tropical vegetable growers.

(9:3) Testing soil samples in laboritory

Chemical soil tests usually indicate - The soil type which is determined mainly by the following:-

1. Soil texture - The texture of the soil and the name of the place in which it was first widely found is used as the name of the soil type. The name of the place is put before the texture eg. Caymanas sandy loam.

2. Internal drainage - The speed at which water moves through a soil. This depends mainly on the soil texture and how permeable the top soil and sub-soil are. Internal drainage might be expressed as:-

   rapid, moderate, slow.

This information gives the grower some idea of the extent to which water conservation (water saving) measures and drainage are necessary. It also gives the farmer some knowledge of the soils ability to hold moisture- (water holding capacity) The word "drainage" is commonly used to refer to the practices applied to a soil to speed up its internal drainage.

3. Soil pH level - The soil test will reveal how acid (sour) or how alkaline (sweet) a soil is. The soil pH influences the extent to which different nutrients will be available and crops that are more likely to do well on that soil.

4. **Amount of available nutrients in the soil.**

The soil test would indicate the level of the primary plant elements (N,P and K), and in some cases, the level of secondary elements (Ca Mg and S), in the soil. An expression of the total available nutrients might also be given. These levels would be expressed as - High, Medium, Low. The nutrient level of the soil like the pH, will be strongly influenced by the parent material from which the soil is formed. In summing up we would say that if the grower knows the result of his soil test, later when he finds the nutrient and moisture requirements of the crops he plans to grow, he will have a good knowledge of -

i) How much water application and drainage is necessary

ii) If it is necessary to correct pH and the quantity of material (eg. lime) would be required.

iii) Grade and rate of fertilizer that needs to be applied to his soil.

<u>In cases where actual tests are not carried out on a farm, soil surveys of the area will usually give enough information that the vegetable grower can use as a guide in place of his soil test</u>. However, the actual location of the land, and how it has been used will cause some difference especially in internal drainage. pH and nutrient levels on the same soil type.

<u>Expressing results of soil tests</u> - A simple code I .

A simple code can be used as a short method for expressing results of soil tests. It is particularly handy for writing many results at the same time. (Later we will see the same system used to express crop requirements, fertilizer grades, plant populations etc). For soil tests, the results will give one feature under each of the 4 headings:-

(9:4)

1. Texture	Symbols.
Sand	S^a
Clay	C^e
Silt	S^i
Loam	L^o

2. Internal Drainage	Symbols
rapid	r
moderate	m
Slow	s

Sandy loam	SL^o
Clay loam	CL^o
Silty loam	S^iL^o
Humus	H^u

3.

Soil pH	Symbols.
Acid	A
Neutral	N
Alkaline	b

Nutrogen	Symbols	Phosphorous	Symbols	Potassum	Symbols
high	N_H	high	P_H	high	K_H
medium	N_M	medium	P_M	medium	K_M
low	N_L	low	P_L	low	K_L

Example I. The results of a soil test shows:-

Soil type Greenvale sandy loam
Internal drainage rapid
Soil pH : acid
Nitrogen: low
Phosphorous : low
Potassum: medium

Using the code the results can be written :-

Greenvale SL^o: r-a-N_L-P_L-K_M

As can be seen, both the results and this code is useful but not good enough for growing vegetables in a scientific and economic way. To begin with, we need to know how acid the soil is for while vegetables can do well if this soil is slightly acid, liming would have to be done if this soil is strongly acid.

Expressing results of soil tests* - Code II

This code can be used by more advanced students. To begin to deal with the problem of levels of acidity, internal drainage and nutrients, the first code can be developed for expressing results as follows:-

cont'd...

(9:5) 1. Soil Texture

Texture	Symbols	% Particles
Sand	S^a	∠80%
Clay	C^e	40%
Silt	S^i	80%
Loams	L^o	About equal
Sandy loam	SL^o	% Sa Cl S^i
Clay loam	CL^o	% Cl Sa Si
Silty loam	S^iL^o	% S^i Sa Cl
Humus	H^u	20 %

2. Internal drainage

Drainage	Symbol	Permeability Inches per hr.
Very rapid	r_I	7.0
Rapid	r	5.1-70
Moderate	m	3-5
Slow	s	2.9-10
Very slow	s_1	∠ 1.0

3. Soil pH

pH levels	Symbols	pH ranges
Very acid	a_1	∠ 5.5
Acid	a	5.5-6.9
Neutral	n	7.0
Alkaline	h	7.1-8.5
Very alkaline	b_1	8.5

4. Available Nutrients

Nitrogen	Symbols	%N (Sands & loam)	%N (Silts & Clays)
Very high	N_{H1}	0.24	0.29
High	N_H	0.17 -0.24	0.20 -0.29
Medium	N_M	0.12-0.16	0.14-0.19
Low	N_L	0.11-0.04	0.13 -0.04
Very low	N_{11}	∠ 0.04	∠ 0.04

Phosphorous	(Symbols)	(ppm P_2O_5)	(ppm P_2O_5)
Very High	P_{H1}	/ 75	/ 125
High	P_H	46-75	76-125
Medium	P_M	30-45	50-75
Low	P_L	29- 7	49 - 12
Very low	P_{L_L}	∠ 7	∠ 12

Example 1. The results of a soil test shows:-

Soil type :	Blue hole clay loam
Internal drainage:	Very slow
Soil pH	Acid
Nitrogen	Very low
Phosphorous	Medium
Potassium	High

Using the code, the results can be written:

Blue hole CL^O : S_1 - a - N_{L1} - P_M K_{H1}

Note - this same system will be used in dealing with correction of soil pH and fertilizer application.

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* This system of expressing results and the standards used are developed from and based on the standard of the Imperial College of Tropical Agriculture (ICTA) Refer to "Arbitrary Quantitative Scheme for assessing Soil Factors" by ICTA 1970.

How to get soil tested.

Here are two ways viz -

1. Ask the government agricultural agency or a private firm to do a chemical soil test.
2. Try to do simple field trials to determine the required features.

The chemical tests give accurate results that the grower can use with a great deal of certainity. If this means is not available then the second method should be attempted. But the vegetable grower should try to get his soil tested particularly before he plants his first crop. Tests should be done after that at least once in 3 - 4 years.

(9:6) Collecting soil samples for chemical tests.

Using a small kit for testing soil pH.

Note - When it is not possible to get chemical tests done and some field trials will be used, try to consult a soil survey map of the area. It will give soil types in the area, and the levels of nutrients. This is information that the grower can use as a basis for his tests.

B. SOIL TYPE AND LAND CAPABILITY MAPS.

Soil Maps - Soil surveys are sometimes done for large areas and sometimes for the entire country. A map is then drawn for the area and the major or all the soil types put on the map. A brief description of each soil type - colour, drainage, nutrient levels, would also be given in the key or notes that goes with the map. Now a farmer or student who is able to get a soil survey map of his area and able to find his district or a nearby one on the map might be able to use the map and the notes with it, to identify his soil type. The information got from this could be used as a guide where a soil test has not been done on the farm.

(9:7)

Land capability map - This shows how suitable a bit of land is for different agricultural purposes. The map is drawn from a survey of the area, and can be used in a similar way to the soil maps. In some cases, both may be put on the same map for a small area.

(9:8)
Land capability

CLASSES	Slope	Features
LC I	$0^{o} - 5^{o}$	Land has deep fertile soil and very suitable for vegetables
LC II	$5^{o} - 10^{o}$	Land suitable for vegetables, but with some limitations
LC III	$10^{o} - 15^{o}$	Land can be used for vegetable cultivation, but needs much improvement
LC IV	$15 - 20^{o}$)	Land not suitable for vegetables, better for grass, tree crop or forestry.
LC V	$20 - 30^{o}$)	

	With		
LC I	e	Erosion	
to	c	climate	Likely to be
LC V	S	Soil	main natural problem.
	W	Waterlogging	

Examples:

I. An area on a land capability map in the Iw Class would be level, but subjected to waterlogging. This is most likely to be an area with stiff clayey soil. With proper drainage, this area would be very good for vegetables.

II An area falling under a IIs Class would have adverse soil conditions. This may be stoniness or other bad features of the soil. If this can be corrected the land will be good for vegetables and most other crops.

CORRECTING SOIL pH.

Importance of correcting soil pH.

Correcting soil pH increases availability of nutrients. The amount of nutrients that plants absorb from the soil is directly related to the production of a crop. Within a certain limit, the more nutrients a plant absorbs, the more it produces. This is true as long as other practices are well applied. But before the crop can absorb the nutrients, it must be available. The amount of any plant element available depends on :-

(1) The total amount that is in the soil i.e. before the nutrient can be available it must be in the soil. It would be madness to expect to get 10 lbs of flour to eat from a box that has in only 5 lbs.

(2) The amount of that total which is available i.e. the amount required might be present in the soil, but not in a form that can be absorbed by the plant. The box might have in 10 lbs or more flour, but only 3 lbs is in a form that can be eaten as flour. The other 7 lbs might not be available because it is mixed with meal. In the soil, the element when present but unavailable to the plant is usually due to the soil pH.

Because different crops require different quantities of each element for maximum production, the pH of the soil must be correct for the crop to absorb the nutrients it requires.

Table showing availability of nutrients at different soil pH levels.

(9:9)

Soil pH level.	N	P	K	S	Ca	Mg	Fe	Mn	B	Cu & Zn
Very acid (a_1) (pH 4.0-4.9)	L	L	L	L	L	L	H	M	M	M
Very acid (a_1) (pH (.0- (5.4)	M	L	M	M	L	L	H	H	H	H
Acid (a) (pH 5.5-5.9)	M	L	M	M	M	M	H	H	H	H
Acid (a) (pH 6.0 - 6.9)	H	H	H	H	M	M	M	H	H	H
Neutral (pH7)	H	H	H	H	H	H	M	M	H	H
Alkaline (b) pH 7.1 - 8.0)	H	H	H	H	H	H	L	L	M	M
Alkaline (b) pH 8.1 - 8.5)	M	M	H	H	H	H	L	L	L	L
Very alkaline (b) (pH 8.6 - 9.0)	M	M	H	H	M	M	L	L	H	L
Very alkaline (b_1) pH 9.1 - (10.0)	L	H	H	H	M	M	L	L	H	L

(L = low, M = medium, H = high)

The table explained.

1. The table shows the quantity of each nutrient available at the different soil pH levels. But for the nutrient to be available in these quantities, adequate supply of each element must be in the soil. The vegetable grower must ensure this. The primary elements (N,P and K) are the ones that are usually in short supply even when the soil pH is correct.

2. Put a straight edge across the table at the pH level that you want to check. The symbols in each box along the edge will show the availability of the nutrient at that pH level if there is adequate supply in the soil.

3. Put a finger at the top of the column for each element. The symbols down the column show the availability of that element at the different pH levels.

If we look at the table, we will see why most vegetable crops grow in slightly acid/to neutral soil, between pH 6 to 7. On more acid soils, there is at least one element that is available in low quantities. The same holds for alkaline soils.

But although slightly acid to neutral is ideal, most vegetables will grow fairly well in acid to slightly alkaline soils, between pH 5.5 to 8.0

<u>Here is a table of the correct pH level for different vegetable crops.</u>

(9:10) <u>Acid to slightly alkaline (pH6-8)</u>

Asparagus
Beet
Brocolli
Cabbage
Cauliflower
Celery
Chard (swiss)
Cabbage (chinese)
Leek
Lettuce
Musk-mellon
Okra
Onion
Spinach

<u>Acid to neutral (pH 5.5 - 7.0)</u>

Beans
Brussel sprout
Carrot
Collard
Corn
Cucumber
Egg-plant
Garlic
Radish
Kale
Kohlrabi
Mustard
Parsley
Parsnip
Pea
Pepper
Pumkin
Rutabage
Squash
Tomato
Turnip

Very acid to neutral (pH 5 - 7)

Endive
Potato
Rhubarb
Water mellon

When the pH level of the soil is outside that required by the crop to be grown, the grower should try to correct the pH, as this will usually increase yields. The extent to which this is done, will depend on economics in the business . The grower should try to correct his soil pH to the extent that it will increase his profits.
Other benefits from correcting pH are:

(1) Materials used for correcting soil reaction supplies some plant nutrients. eg. sulphur used to reduce soil pH (ie make soil more acid), and lime to increase pH (ie make soil less acid). These materials supply some plant nutrients. Most commonly used liming material (burned lime, hydrated lime, limestone) supply calcium. Dolomite limestone supplies both calcium and magnessium. However if the soil is not short in these elements applying lime does not help much in this way. Sulphur, sulphuric acid and certain fertilizers are also used for correcting soil pH. These also supply plant nutrients in different quantities.

(2) Improves the structure of heavy soils.

The correcting material is usually a lighter material than heavy soils e.g. 1 cubic unit of dry lime weighs less than 1 cubic unit of heavy soil. The effect of adding a lighter material to a heavier one is that it makes the whole mixture lighter. The net effect is that the structure of the soil is improved.

Reducing soil acidity.

Soil acidity is usually reduced by adding lime in one form or another.

Although the results of a soil test or a soil survey show that a soil is acid, this does not mean a vegetable grower has to apply lime to his soil. He must first check the pH requirement of his crops and compare it with the pH of his soil. If the soil pH is lower that recommended for growing the crop then he should apply the amount of lime needed to raise the soil pH (ie make soil less acid) as is required by the crop.

Example.

If the soil test results show that the soil is acid and the farmer plan to grow cucumber, tomato and water mellon, then he does not need to apply lime. Why is this so? If we look at the pH requirement of the crops, we will see that cucumber and tomato will do well on acid soil, while watermellon will grow well on very to slightly acid soil. But suppose he was growing cabbage which can produce near to optimum on slightly acid soil, then he needs to add lime. He should apply enough to raise his pH level to between 6 and 7 . (See Table 9:10)

Now the vegetable grower is definite that his soil needs lime, he has to decide on the type of liming material he is going to use and how much of this his soil needs to correct the pH.

Liming materials

Here are the commonly used liming materials. They are listed according to their strength (or total neutralizing power (TNP) and the approx quantities required to have the same effect on soil pH as 100 lbs of burned lime.

(9:11)

Liming materials		Approx. equivalent of 100 lbs burned lime (CaO)			To convert to CaO
Slake lime	CaO	100 lbs	or	(50 Kg)	-
Quick lime	Ca $(OH)_2$	125 lbs		(62 Kg)	x 1.25
Dolmitic limestone	Ca CO_3 Mg CO_3	135 lbs		(68 Kg)	x 1.35
Ground limestone	Ca CO_3	200 lbs		(100Kg)	x 2
Marl	Ca CO_3	200 lbs		(100Kg)	x 2

Other substances that can reduce soil acidity (i.e. alkaline substances) are:-

Calcium nitrate or nitro-chalk	Ca $(NO_3)_2$	500 lbs	or	(250 Kg)	x 5
Nitrate of potash	KNO_3	400 lbs		(200 Kg)	x 4
Nitrate of soda	Na NO_3	300 lbs		(150 Kg)	x 3

Neutral materials.

These materials when added to soil neither make the soil more acid nor more alkaline. They are:-

Ammonium nitrate	NH_4 NO_3
Calcium sulphate (gypsum)	Ca SO_4
Muriate of potash	KCl
Sulphate of potash	K_2SO_4
Super-phosphate	P_2O_5

How much lime to apply (General recommendations)

Approx. quantity of slake or burned lime (Ca 0) required to reduce the acidity on different types of soils. (All figures refer to the changes in pH of the depth of soil ploughed)

(9:12)

Changes in pH level	Quantity of lime (lbs/sq. chn & Kg/400 sq.m)		
	Sandy soils	Lcams	Clay soils
From pH 5.5 to 6.5	250 lbs. (125 Kg)	350 lbs (175 Kg)	450 lbs (225 Kg)
From pH 5.0 to 6.5	350 lbs (175 Kg)	450 lbs (225 Kg)	650 lbs (325 Kg)
From pH 4.5 to 6.5	425 lbs (212 Kg)	575 lbs (288 Kg)	850 lbs (425 Kg)
From pH 4.0 to 6.5	500 lbs (250 Kg)	700 lbs (350 Kg)	1000 lbs. (500 Kg)

To determine the amount of other liming materials to use, multiply the quantity of lime by the figure in the last column of the previous table.

Example: To correct the pH of a moderate to a slightly acid sandy soil, would need about 250 lbs burned lime or 250 x 2 = 500 lbs per sq. chn of ground limestone.

Note - For changing the pH of very strongly acid to slightly acid soils, the total quantity should not be applied in one application. Apply a half at first, and then the otherhalf in a second application about 6 months later. Applying the lime in a single application might cause over-liming. This cause problems of nutrient deficiency especially trace elements. For all quantities, after this first generally recommended application, lime should be added at about once each year. A quarter of this general recommendation would be suitable.

Do not apply lime before ploughing. At ploughing the lime would be put too deep into the soil for it to correct the pH of the entire ploughed layer. This holds despite the method used in spreading.

3, Harrow the field once or twice as required to work the lime into the soil.

How to spread lime

The methods that a vegetable grower uses to spread lime will depend largely on the amount of lime to be applied (note that lime can be applied at the same time as some organic manures). Here are some suggestions

For liming small areas (under 1 acre)

One method

1. Plough the land.

2. Put the lime in a box, bucket or some other suitable container. Walk through the field and spread the lime over the entire area. Try to distribute it evenly. To do this, the grower could roughly divide his field into square chains. Apply the required quantity for each square chn.

3. Harrow the field once or twice as required to work the lime into the soil.

Another method

1. Plough the land
2. Harrow the field once
3. Put the lime in a wheel-burrow and with one person pushing and the other spreading, the lime can be quickly distributed over the field. Try to distribute it evenly.
4. Harrow the field again. This should work the lime into the soil sufficiently.

For liming large areas

1. Plough the land.
2. Put the lime in the trailer of the tractor and distribute as the tractor drives over the area.

   A lime / fertilizer spreader can also be used. The vegetable farmer could hire this from a cattle farmer who uses it to lime or fertilize his pasture. It is not recommended for a vegetable farmer to buy this equipment as liming is not a practice that is frequently done. This equipment is not suitable for fertilizer application in vegetables.

INCREASING SOIL ACIDITY.

On alkaline soils, for growing most vegetable crops, the soil has to be made more acidic. To do this, materials that form acids in the soil is usually added. The most commonly used are:-

(1) Acid - forming fertilizers

(2) Soil sulphur

(3) Sulphuric acid.

Applying acid-forming fertilizers and soil sulphur are more often used as sulphuric acid is a dangerous substance to work with. In addition, fertilizers also add nutrients to the soil.

Here is a list of acid - forming materials and the quantity required to have the same effect as 100 lbs soil sulphur.

(9:13) Acid-forming material		Approx. equavalent of soil sulphur of 100 lbs or 50 Kg	To convert to S
Soil - sulphur	(S)	100 lbs or (50Kg)	-
Ammonium nitrate	$NH_4NO_3^*$	1000 lbs (500Kg)	x 10
Ammonium phosphate	$(NH_4)_2PO_4$	1000 lbs (500Kg)	x 10
Ammonium sulphate	$(NH_4)_2SO_4$	650 lbs (325Kg)	x 6.5
Urea	$CO(NH_4)_2$	700 lbs (350Kg)	x 7

* Note the plant elements added by each acid-forming material.

How much sulphur to apply (General recommendation)

Approx. quantity of soil sulphur (90% S) needed to increase acidity on different types of soils.

(All figures refer to changes in pH of the depth of soil ploughed)

(9:14)

Changes in pH level	Quantity of sulphur (lbs / sq.chn)orKg /400 sq.m		
	Sandy	Loamy	Clayey
From pH 7.0 to 6.5	10 lbs or (5 Kg)	15 lbs (8Kg)	30 lbs (15 Kg)
From pH 7.5 to 6.5	50 lbs or (.25 Kg)	80 lbs (40 Kg)	100 lbs (50 Kg)
from pH 8.0 to 6.5	120 lbs (60 Kg)	150 lbs (75 Kg)	200 lbs (100 Kg)
From pH 8.5 to 6.5	200 lbs (100 Kg)	250 lbs (125 Kg)	300 lbs (150 Kg)

To determine the quality of other substance to be used instead of sulphur, multiply by the conversion factor in the previous table, just as with liming materials. The method of applying soil sulphur will be very similar to applying lime.

Chapter 10. APPLYING MANURES AND FERTILIZERS

A. APPLYING ORGANIC MANURE

Importance of applying organic manures.

It is important for the vegetable grower to apply as much manure to his soil as is economically sensible.

Organic manures improves the soil in many ways and as such, is often beneficial to the vegetable grower when applied - How?

1. Organic manure improves the structure of a soil i.e. on sandy soils and soils of rapid drainage, when the manure decays, it helps the soil to hold more moisture. Loss of nutrients from leaching is also reduced. On clay soils, adding organic manures, improves the drainage and aeration of these soils.

2. Organic manure supplies plant nutrients i.e. when it decays, the elements that make up the manure are released and made available to the crop.

3. Organic manure increases availability of nutrients i.e. during the decomposition (decay) of the manure, the soil organisms (bacteria, fungi etc) involved in the process release certain acid substances. These acids affects the soil pH and availability of nutrients.

4. Organic manure increases root penetration i.e. the decayed matter improves the overall physical condition of the soil. The roots of the crop can move through the soil more easily in search of food. The result is usually increased production of the crop.

5. Some organic materials also act as mulch when applied to the surface of soil. eg grass, corn fodder.

Improving land with little top soil

Because the land has little top soil, at ploughing much subsoil is brought to the surface. This material is usually of poor structure and low in nutrients. In harrowing the field, it will mix with the top soil, making the whole ploughed layer poor for growing the crops.
Application of organic manures is the best means of improving such soils.

Types of organic manures.

Organic manures are of 2 main types viz

(a) Animal manures i.e. manures from animals.

(b) Plant manures i.e. manures from plants.

Here are some commonly used manures and their chemical composition.

Animal manures with normal quantity of bedding

(10:1)

MANURE	Per cent moisture	(Approx. composition in lbs / ton)*			
		Nitrogen	P - acid	Potash	Tot nutrients
Cow	86%	11	3	10	24 lbs
Hen	73%	22	18	10	50 lbs
Hog	87%	11	6	9	26 lbs
Horse	80%	13	5	10	28 lbs
Sheep	68%	20	15	18	53 lbs
		(Percentage dry matter of manure)			
Bat guano	-	10	4	2	16%
Blood	-	13	2	1	16%
Bone-meal	-	3	15		18%
** Sewage-sludge	-	1.5	1.3	0.4	3.3%

---

* Multiply figures by 1/2 to convert to kilo per 1 tonne.

** Sewage sludge is more important for improving the physical condition of a soil than for supplying nutrients.

Plant manures

MANURE	Per cent Moisture	(Approx. composition in lbs / ton)			
		Nitrogen	P-acid	Potash	Tot. nutri-ents
Bean (straw)	11%	20	6	25	51 lbs
Sudan-grass (straw)	10%	23		1	24 lbs
Sweet corn (folder)	12%	29	8	24	61 lbs

How to prepare organic manure.

Organic manure improves the soil when it decays and forms humus in the soil. But it can be applied to the soil as:-

- fresh material i.e. fresh animal and plant manure applied to soil

- partly or totally decayed material i.e. the animal and plant manure put to rot for later application. The material is then cal ed compost.

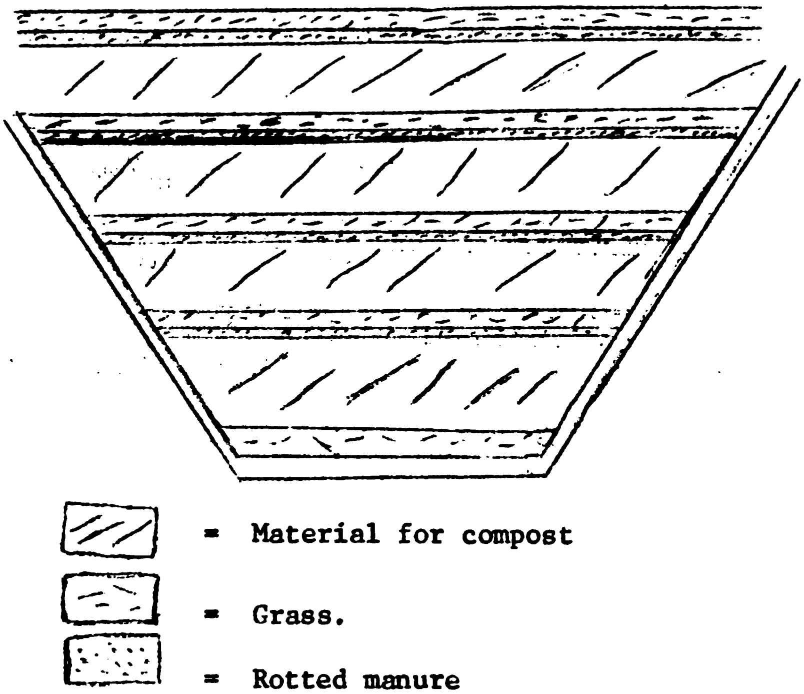
Composting -This is the means of preparing the compost. The time that the compost takes to be prepared depends largely on the type of material from which it is made and to what extent it is made to decay before it is applied. Because, the longer the material remains, the more it breaks down. But the vegetable grower might apply it at different stages depending on his preference. The farmer should consider the economics (eg. cost of application) in deciding at what stage he applies his material. It is usually best to apply when the material is almost totally decayed.

Preparing the compost.

Pit method.

Steps - 1 Digging the pit - Dig a hole or trough not more than 12 - 18 ins deep (or 30 - 45 cm).

The diameter should depend on the amount of material for compost . Try to implement some means of reducing seepage (eg thin layer of concrete) at bottom or few sheets of zinc. The sides of the pit should slope inward for the bottom to prevent the sides from caving in. The pit will reduce the amount of nutrients washed out by rainfall and the composting takes a shorter time. The pit should be located near the field and in a shaded area.



(10:2) Arrangement of material in compost heap.

Making the heap - Put a layer of the material for compost (about 3-6 ins or 7 - 15 cm thick) at the bottom of the pit. If possible, spread a thin layer of already rotted manure. This will introduce soil organisms (mainly bacteria and fungi) and will speed up the decaying process. If the material for compost does not include dry grass, start with a layer of dry grass at the bottom of the heap and the top of each layer of the material. Continue to put in grass, material for compost rotted material in layers until the desired amount of material is included. If fertilizer is to be added, apply either mixed with the material for compost or above the rotted manure. The heap should not be more than about 3 ft. high (approx. 1.m) as it will be necessary to turn the material. Over 3 ft. it will be a difficult task.

It is unlikely that all the material will be stacked at the same time but the same pattern of organization should be followed.

Try to keep a layer of grass at the top of the heap as covering. This reduces moisture loss from the heap.

3. Wetting the heap - The heap should be wet at intervals to keep it moist. It should not be kept soaking wet as this will starve the organisms of oxygen and reduce the speed of composting. It will also make it difficult to turn the heap.

4. Turning the heap - The heap should be turned at intervals of 2 - 4 weeks. This allows passage of air and mixing of the organic material.

5. Removing compost - Composting should be finished in 3 to 4 months. This will depend on what stage it will be applied to the field. The well decayed material will be dark in colour with the dried material loose and resembling soil.

Stack method.

The major difference between the stack and pit methods is that in the former the material is piled up into a heap without a pit dug. The vegetable farmer should use the method that is most suited to his conditions. For instance, if he is in a rainy area, he would do well to use the pit method as it will help to reduce the amount of nutrients that will be washed out of the heap. Alternatively, he could cover the heap.

Advantages in using compost

1. Composting reduces the bulk of the material to be applied. Most fresh manures are bulky,with most of the bulk in water. In composting water is lost and this reduces the quantity of material. The total effect of applying the compost is the same as if the fresh material was added except that in the compost, a part of the decomposition (breaking down) takes place outside the soil. Because the bulk of the material is reduced (to as much as 1/3 original volume), this reduces cost of application.

2. The composts improves the soil more rapidly than when the fresh material is added. The effects is often shown on the crop earlier. The fresh material when applied usually benefits later crops.

3. During composting the majority of the weed seeds that were in the fresh material are destroyed. This reduces the problem of introducing weeds into the field which is a major set-back in using the fresh organic material.

How much manure to apply

The quantity of manure to be applied to a field would depend largely on -

1. Type of soil to be manured.
2. Manures to be applied and crops to be planted.
3. Amount of manure available.

The type of soil is important in that sand and clay soils usually require more manure than loam soils. However all soils are improved by adding manure. The amount of manure that the grower can get to apply to his field is important factor. To improve soil, it has to be applied in large quantities compared to lime or fertilizers. The type of manure is important because of its chemical composition eg. smaller quantities of poultry manure than cow manure should be added to vegetables as the high nitrogen content will cause excess leaf growth. It is for this reason that this manure is applied in large quantities in cultivation of leaf crops.

Here are some general recommendations

Apply manure between 5 - 20 tons / acre of organic manure. (approx. 10-40 tonne per hectare)

1. Apply smaller quantities of partly or completely rotted material than fresh material.

2. Divide the total amount available to allow application to the entire area to be manured eg. if 2 acres is to be manured with 16 tons of manure apply at the 5 tons / acre rather than 10 tons to the acre.

3. Apply more organic manure to clay and sands than to loam soils.

4. The higher the N - content of the manure, either apply it at a lesser rate or reduce the quantity of nitrogen in the fertilizer later applied to the crop. Do not apply more than 5 tons / acre of poultry or sheep manure in a single application except to leaf vegetable. The high N-content encourage much leafy growth and poor root and fruit formation. Devise a convenient means of measuring the manure.

Example.

Find the approx. wt. of a box of the material. Then if a wheel burrow is to be used in transporting the manure, find how many boxes of the material will fill the burrow. This will give the approximate weight of each burrow full. Then the number of burrow-full of material can be used as an estimate for rate of application.

How to apply organic manures.

1. If the manure is added mainly for supplying nutrients, it can be spread on the surface of the soil. This also holds if it is applied as mulch.

2. If the manure is applied mainly for improving the physical condition of the soil, then it should be spread on the surface after ploughing and later harrowed into the soil.

3. It is 'good' to spread some powdered pesticide on the manure during application. This is especially helpful to control insects and other pests in the manure.

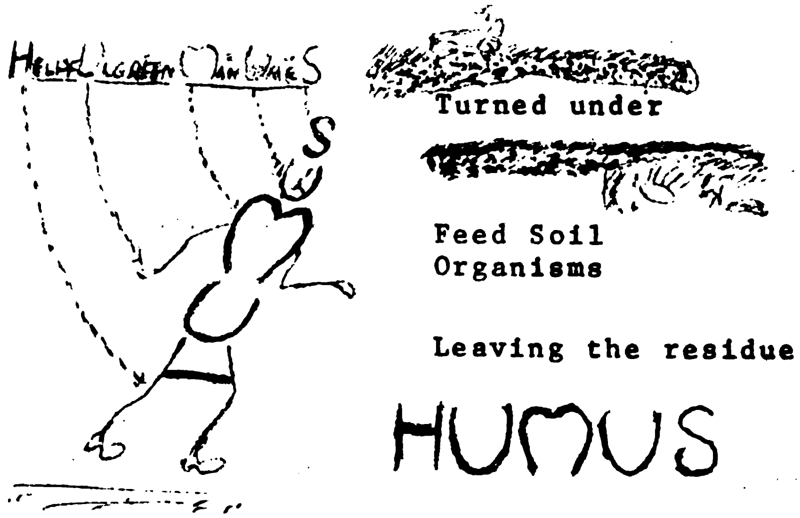
Application - The actual application of the organic manures can be done in essentially the same way as in liming. It is for this reason that sometimes when it is necessary to lime and manure a field, the required quantity of each is mixed and both applied together.

A manure spreader can also be used. It is a bit of machinery specially made for applying organic manure. But with manual application, to get as fairly even spread of the material, it is best to spread it in blocks. For example if we want to spread 100 burrow-ful of manure to an acre, try to put about 10 burrow-full on each square chain of land and then spread the manure.

Ploughing crop remains into the soil.

After reaping a crop, the vegetable grower can plough in the weeds and remains of the crop into his soil. Legumes are particularly helpful with the high supply of nitrogen in nodules on their roots. He can do this immediately after reaping, or 2-4 weeks later when the weeds grown some more.

It is important to bear in mind that the remains of a crop that was seriously attacked by disease might build up the pests and attack the following crops. Apart from this, the vegetable grower will find that ploughing in his crop remains is beneficial.



Turned under

Feed Soil
Organisms

Leaving the residue

HUMUS

Problems in using organic manures.

1. Manures are usually difficult to get in the required quantities.

2. Manures are usually more costly to apply.

3. Some manures contain seeds of weeds (eg. grass seeds in animal manures). These later add to the problem of weed control than fertilizers.

4. Some manures might also have diseased organisms in them which will later attack the crop. This is particularly true of compost made from remains of diseased vegetable crops. They might also harbour insects that will later attack the crop.

C. APPLYING FERTILIZER.

What are fertilizers?

Fertilizers are manufactured substances that contain one or more plant food element. When fertilizers are applied to crops, they usually caus increase growth or planting, or as a side dressing after planting. It may be sprayed in a solution on the foliage of the plant i.e. foliar apray. But, the fertilizer has to be in a solution either when applied or after, before the nutrients can be absorbed by the crop.

Most fertilizers contain one or more of the 3 primary nutrients, in the available form-nitrogen (N), phosphate (P_2O_5) and potash (K_2O). If we look on the chemical formula in the bracket for each substance, we will see where the N,P and K usually written on the bag of the fertilizer, comes from.

What are fertilizers made from?

Most fertilizers are made from rocks. A few are made from the excrement of bats, birds and remains of animals and plants. Also some ar by chemical processes in a laboratory. Calcium cyanamide and urea are two examples of synthetic fertilizers. But the majority of fertilizers are made from rocks.

How?

In some places there are large area of soft rocks, rich in one or more plant elements. This raw material is mined and transported to the factory. At the factory, they are processed to produce the required fertilizers.

A note to farmers.

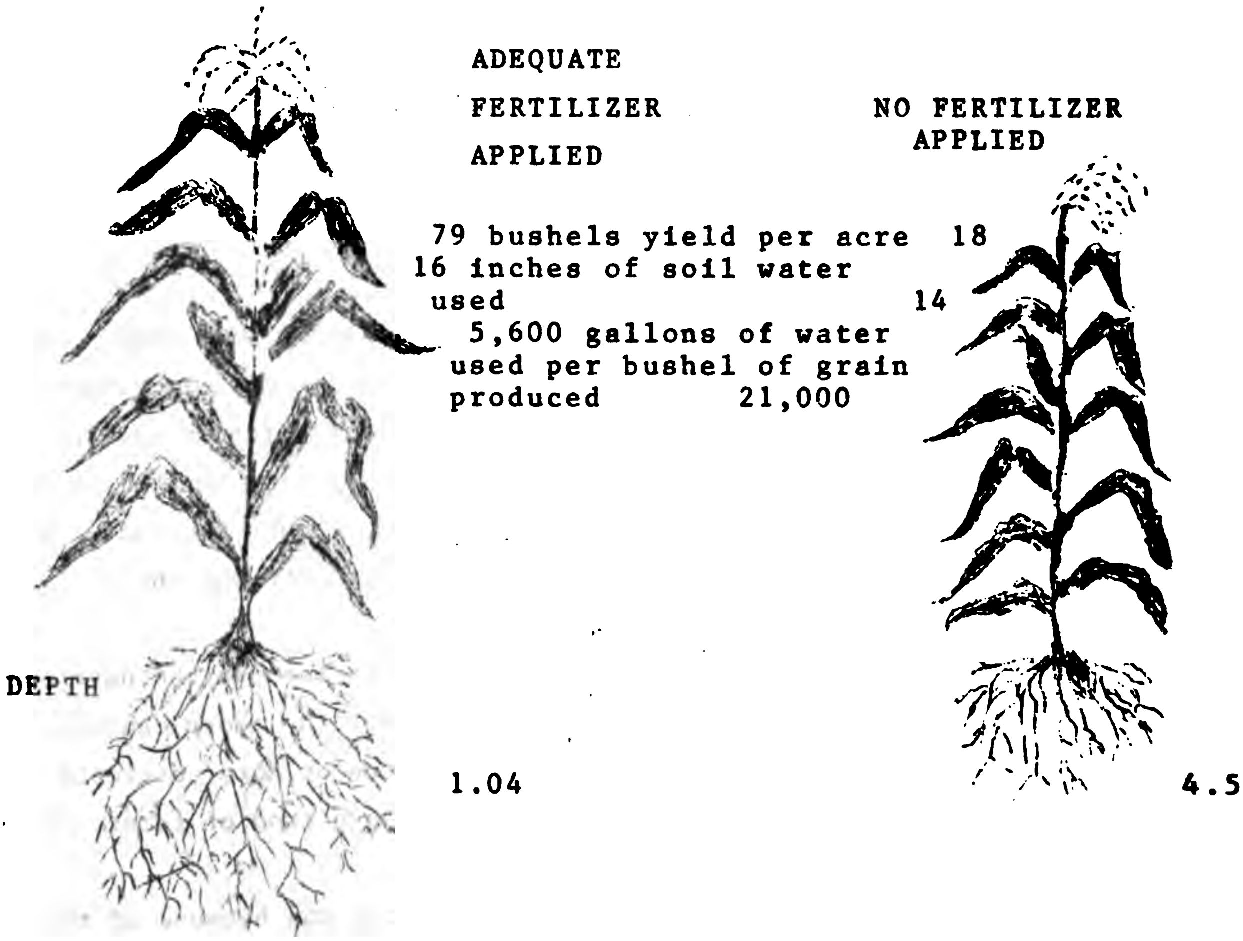
Farmers should pay particular attention to what makes fertilizers. This is so as many farmers have the idea that fertilizers reduce the quality of the food (i.e. poor taste and storage quality). This might have some truth in it. But, it is not because fertilizers are bad substances. On the contrary, fertilizers are good but we must learn how to handle them. It is like a motor car. It is good when we know how to handle it, but will create havoc when we don't.

Now fertilizers speed up growth. There is nothing wrong with that. But, some farmers are used to reaping watermelon for example when it reaches a certain size when grown without fertilizer. Now if the farmer applies fertilizer and reap the crop at the same size, he may find that his watermelon is fresh, and cannot be stored for long. One cannot say that fertilizer do not have flaws but the good points outweigh the bad ones.

Most plants cannot grow on rocks. This is so mainly because the nutrients have to be absorbed in solution by the plant. Also, the roots cannot penetrate the rock. No matter how rich a rock is in one or more nutrients, if the rock is even soft, we would not be able to reap a crop of tomato from it

At one place we will find soil poor in an element and because of this gives low yields and at another place we have rocks rich in an element but plants cannot grow there. The logical thing is either to move the soil to the rocks or the rocks to the soil and mix them. But we all know it is easier to move the rock to soil. Hence rocks are mined, refined, put in bags as fertilizers and transported to the field.

The result for example is - Soil poor in P+P rock (fertilizer) → soil rich in P.


ADEQUATE FERTILIZER APPLIED
NO FERTILIZER APPLIED
79 bushels yield per acre 18
16 inches of soil water used 14
5,600 gallons of water used per bushel of grain produced 21,000
DEPTH
1.04
4.5

Importance of applying fertilizers.

1. Fertilizers supply plant nutrients.

Supplying nutrients to a soil when these are in short supply (deficient) usually increases growth and yield of the crop planted on such soil.

Fertilizers and soil pH - Remember that the fertilizer might be applied to the soil, but is not available to the plant if the pH of the soil is not correct. For example, phosphorous when applied to moderately or strongly acid soil, will tend to become fixed and will be available to the crop only in small quantities. In this case this fertilizer should be applied with organic manure.

(See pH and availability of elements)

2. Fertilizer helps the crop to make better use of moisture. This is a very important point that vegetable growers should know, but, they should also note that although it helps the plant to use moisture more efficiently and helps the crop to develop a better root system to absorb more water , it does not supply moisture

The water must be applied to the field before the fertilizer can help the crop to make better use of the moisture.

(10:4) Fertilizers helps crops to make better use of moisture and increases growth and production.

Terms Related to Fertilizers

Fertilizer Grade (or Analysis)

This refers to the percentage of each plant element in different types of fertilizers .

Generally these fertilizers are:-

(1) Single (or straight) fertilizers - which contain only one element.

Example. Sulphate of Ammonia has a grade of approx. 21% N

Single Super- phosphate 18% P

Double Super - phosphate 30% P

Triple Super - phosphate 48% P

Muriate of potash 60% K

2. Mixed fertilizers - These contain more than one plant nutrient. This includes

(a) double fertilizers - containing 2 elements

Examples- Potassium nitrate contains 14% N and 46% K

The grade can be written as NK / 14 - 46

(b) triple fertilizers - containing 3 elements

A triple fertilizer containing all 3 primary elements is called a complete fertilizer.

Examples - Calcium nutrate contains 15% N and 20% Ca

Its grade can be written as NCa / 15 - 20

Example 1.

N - P - K -, 10 : 10 : 10 means that the fertilizer contains -

10% Nitrogen (10% N)
10% Phosphorous (10% P)
10% Potassium (10% K)

The grade of this fertilizer can also be written - NPK / 10 - 10 - 10

Example 2.

N - P - K , 5 : 10 : 20 means that the fertilizer contains -

5% Nitrogen (5% N)
10% Phosphorous (10% P)
20% Potassium (20% K)

Its grade can be written as NPK / 5 -10 - 20

Fertilizer Ratio.

This refers to the proposition of each element in the NPK mixture. It can be calculated by dividing the percentage of each element by the lowest percentage in the mixture.

$$\text{Ratio} = \frac{\%N : \%P : \%K}{\text{lowest \% in mixture}}$$

Example 1.

In a NPK / 10 - 10 - 10

$$\text{Ratio} = \frac{10 : 10 : 10}{10} = 1 : 1 : 1$$

Example 2. In NPK / 5 - 10 - 15

$$\text{Ratio} = \frac{5 : 10 : 15}{5} = 1 : 2 : 3$$

Example 3. In NPK / 15 - 10 - 20

$$\text{Ratio} = \frac{15 : 10 : 20}{10} = 1\ 1/2 : 1 : 2 \quad \text{or} \quad 3 : 2 : 4$$

(See fertilizer levels vs ratio [illegible])

Rate of application.

This refers to the amount of a fertilizer that is applied to a soil per unit area. Rates are usually expressed as quantity fertilizer per acre and per, hectare

Example - A recommended rate for a crop on a given soil would be:-

500 lbs per acre (i.e. 5 hbs / acre)
or 50 lbs per sq. chn.
or 500 Kilograms per hectare
or 25 Kg. per 400 sq. metre.

Carrier or filler material

A carrier or filler is the material in which the nutrients are carried in a fertilizer. In other words, most fertilizers are made up of plant nutrients and a carrier. In cases where a small quantity of fertilizer is to be applied, sand may be used to increase the amount of filler material.

Example - If 10 lbs of fertilizer is to be applied to a square chain of land, another 10 lbs of sand can be mixed with the fertilizer and the mixture applied. This will allow for the fertilizer to be more evenly distributed.

(10:5) Some commonly used fertilizers and the approx percentage of plant element (s) they supply

Fertilizers	Grades	Fertilizers	Grades
Ammonium nitrate	33% N		
Ammoniated Super-phosphate	NP/4-16	Magnesium sulphate	10%Mg+S
Mono-Ammonium phosphate	NP/11-48		
di-Ammonium phosphate	NP/21-53		
Ammonium sulphate	21%N	Muriate of potash	60% K
Liquid ammonia	82%N	Potassium Nitrate	NK/ 14-46
Liquid ammonium hydroxide	12-25%N	Potassium Sulphate	app. 50%K
Liquid ammonium phosphate	NP/8-24		
		single Super-phosphate	18-20% P
Borax	11%B	triple Super-phosphate	48% P
Calcium Cyanamide	21%N+	Nitrate of soda	
Calcium nitrate	15%N+Ca	or Sodium nitrate	16%N
		Urea	45%N
Copper sulphate	25% Cu +S	Zinc sulphate	23%Zn +S

\+ Complete Fertilizers (N - P - K) of many different grades

Vegetable growers should know the percentage of the plant elements in a fertilizer. This helps him to determine the amount of that fertilizer he needs to use and the more economical fertilizer to buy.

D. FERTILIZER RECOMMENDATIONS.

General recommendations are made for growing a crop under a range of conditions. General fertilizer recommendations for a crop on a range of soil conditions can be given in a book. But, the specific recommendations can only be given after tests are made of soil conditions on the farm. This holds for all recommendations on different practices in vegetable production. (This book seldom gives specific recommendations as it is a general book not written for a specific area. Recommendations should be used as guides.)

Suitable fertilizer recommendations are important because:-

1. The vegetable grower must try to make the most efficient use of fertilizers. This can best be done when the correct fertilizer is applied at the most economical rate for the existing soil conditions. This is why it is important that the vegetable grower try to get the correct recommendation in fertilizers (grade and rate of application) for growing each crop on his farm.

2. Unlike lime or manures, fertilizers are applied regularly and are more expensive per unit weight. Lime for instance if applied at all, might be applied in large quantities once in 3 years. This is not true of fertilizers. They are usually applied more regularly on a wider range of soils. It means that the fertilizers have to give good returns to the grower to cover both the cost of the material and for the application in addition to increase profits to the business.

Fertilizer recommendations are usually given in one of two ways. viz :-

- by weights of elements - (E_w - method.)
- by grades and rates - (GR - method.)

Fertilizer recommendation by weight of elements - (Ew method.)

There are some cases in which the recommendation for growing a crop is given only as the weight of each primary element on a per acre basis eg. the recommendation rate for growing corn on a particular soil type might be 60 lbs N, 40 lbs P, 30 lbs K (per acre or in kg. per. ha.) Neither the grade of fertilizer to be used or its rate is given. The vegetable grower has to determine this. - How?

Steps. (Using separate fertilizers)

1. Decide on the fertilizers to be used. The 3 elements might be supplied by separate fertilizers.

2. Find out the analysis of the fertilizer

3. Use this formula to determine the approx. rate (R) of application -

$$\text{Rate} = \frac{\text{Reqd. wt. of element}}{\text{\% of element in fert.}}$$

$$\text{i.e } R = \frac{\text{Reqd. wt. } E}{\text{\% of E in fert.}} \quad / \text{ where E } = \text{element}$$

Example 1.

If a recommendation for growing corn is given as 60 lbs N, 40 lbs P and 30 lbs K, how much fertilizer is to be used.*

Using separate fertilizers.

Sulphate of amonia (20%N), triple super phosphate (50%P) and muriate of potash (60%K)

$$\text{Rate (sulphate)} = \frac{60 \text{ lbs}}{20/100}$$

$$= \frac{60 \times 100}{20} = 300 \text{ lbs}$$

$$\text{Rate (super-phosphate)} = \frac{40 \text{ lbs}}{50/100}$$

$$= \frac{40 \times 100}{50} = 80 \text{ lbs}$$

$$\text{Rate (potash)} = \frac{30 \text{ lbs}}{60/100}$$

$$= \frac{30 \times 100}{60} = 50 \text{ lbs}$$

Mix the required amount of the 3 fertilizers and apply the mixture.

Steps (Using a complete (NPK) fertilizer)

1. Find the ratio of the quantities to be applied.
2. Decide on a NPK fertilizer with approx. the same ratio.
3. Use this formula to determine the approx. rate (R) of application

$$\text{Rate} = \frac{\text{Required total nutrients}}{\text{total \% NPK in fert.}}$$

$$\text{i.e. } R = \frac{\text{Reqd. NPK}}{\text{Fert. NPK}}$$

* Multiply by 1/2 to convert to kg.

Example

If a recommendation for growing corn is given as 60 lbs N, 40 lbs P and 30 lbs K, what grade and rate of application should be used.

Ratio $= \frac{60 \;:\; 40 \;:\; 30}{30}$ $\quad 2 : 1\ 1/3 : 1$

OR approx. $6 : 4 : 3$

Reasonable grades would be NPK/ 15 - 10 - 8 or 20 - 14 - 10 If 15 - 10 - 8 is used.,

Rate $= \frac{130}{33\ /\ 100}$ ie. appr x. 400 lbs / acre

If 20 - 14 - 10

Rate $= \frac{130}{44/100}$ ie. approx. 275 lbs / acre

Here are some general recommendations for the main vegetable crop groups giving the weight of nutrients to be applied in the fertilizers. (Figure in lbs / ac or kg /ha)

(10:6)

Crops	Soil Texture	Soil Nutrient Levels								
		N			P			K		
		Low	Medium	High	Low	Med.	High	Low	Med.	High
Legumes	Sandy soils.	50	40	30	100	80	60	80	60	40
	Clays, loams) and Silts	40	30	20	100	80	60	60	40	25
Fruit Vegetables	Sandy soils	100	80	60	80	60	30	80	60	40
	Clay, loams) & Silts	80	60	40	80	60	30	60	40	25
Root Vegetables	Sandy soils	80	60	40	80	60	30	100	80	40
	Clay,loams) & Silts	60	40	20	80	60	30	80	60	30
Leafy Vegetables	Sandy soils	120	100	80	60	40	25	80	60	40
	Clay,Loams) & Silts	100	80	60	60	40	25	60	40	20

1. The table is based on recommendations taken from Bulletin No. 2. by CARDI - (Caribbean Agricultural Research and Development Institute)

2. Where irrigation or rainfall is not adequate, reduce the application rates by about 20%.

3.

Soil Nutrient Levels	Remarks.
Low	Crop show dificiency symptoms and crop failure likely if nutrient not applied.
Medium	Fertilizer needed to achieve optimum crop yield
High	Adequate supply of element, but small amount of fert. applied as side dressing to ensure optimum crop yield.

The recommendations given in Table (10:16) can be used on crops falling within the different groups.

Example: Cucumber can be grown on a sandy soil with Soil NPK / L-M-H using 100 lbs N, 60 lbs P and 40 lbs K in fertilizers. The same recommendation could be used for tomato on sandy soils.

Later we will try to go a little further and try to make recommendations for each crop on different soils.

Problems with recommendations expressed in weights of each element.

As we have seen in this method of giving recommendations, the grade and rate of application not given. This has the advantage of allowing the vegetable grower to choose the grade to be used and to calculate the rate of such grade.

But this same point has its problems. The chief one is the difficulty of calculating a suitable fertilizer ratio to determine the grade and the further need to calculate the rate of this grade. This makes it particularly difficult for vegetable farmers to use the method. Then there are the problems of having to mix those compartible with each other. A straight grade and rate of applying a complete fertilizer is more useful to the farmer.

Fertilizer recommendations by grades and rates - (GR method

In making fertilizer recommendation in this way, 2 sets of information are given i.e.

1. Grade of fertilizer to be used for growing the crop on that soil.

2. Rate of fertilizer application for growing the crop at a given population on that soil.

Example:

1. A fertilizer recommendation for growing beans on X sandy loam would be NPK / 10-15-10 at 5 hbs / acre or 500 kg / hectare.

2. A fertilizer recommendation for growing Beans on Y clay loam would be NPK / 15-10-10 at 4 hbs / acre or 400 kg/ha.

Calculating the weight of each element (Ew) in a given fertilizer recommendation.

In giving fertilizer recommendations by the weight of each element (E_w- method) we saw where the weight of each element to be applied is given. However, in certain case, we will find that we are given a recommended grade and rate of application, (GR - method)and we have to find the weight of each element (E_w) in this recommendation. This is true particularly where we have to mix fertilizers and in certain experimental work.

To find the weight of each element in a given recommendation. This formula can be used:-

Weight of element = % of element in fert. x Rate of application

i.e. E_w = % of E x R

Example.

In a recommendation of NPK / 10-15-20 at 3 hbs / acre, the weight of each element is -

Wt. of N = 10 x 3 = 30 lbs

wt. of P = 15 x 3 = 45 lbs

wt. of K = 20 x 3 = 60 lbs

Here is a general formula that can be used for mixing fertilizers.

Quant. NPK fert. = Reqd Quant. N + Reqd.Auant P + Reqd. Quant of K.

$$\text{Where Reqd Quant. of E- fert.} = \frac{\text{Wt. of E in recom.}}{\text{\% of E in fert.}}$$

Note - One close resemblance of this to the formula used in E_w method .
In that formula, the required weight of each element is given in the recommendation while in this case it has to be found.

To use the formula

Steps

1. First we have to find the weights of N,P and K in the recommendation.

2.

2. Then find the quantity of each fertilizer to be used in the mixture.

3. Add the separate quantities. These would be mixed and applied to the crop.

Example 1.

A vegetable grower wants to use a recommendation NPK / 10-15-20 at 300 lbs / acre on a crop. He does not have this fertilizer, but has sulphate of ammonia(20%N), triple-super-phosphate (50%P) and Muriate of potash (60%K).
He wants to mix these to get the equivalent quantity of NPK in the recommendation.

To find the weights of N,P and K in the recommendation:
Using the formula

$$E_w = \% \text{ of } E \times R$$

Wt. of N = 10 x 3 = 30 lbs
Wt. of P = 15 x 3 = 45 lbs
Wt. of K = 20 x 3 = 60 lbs

To find the quantity of each fertilizer to be used in the mixture.
Using the formula

$$\text{Reqd. Quant. of E - fert.} = \frac{\text{Wt. of E in recomm.}}{\% \text{ of E in fert.}}$$

Reqd. Quant. of N-fert. $= \frac{30}{20/100} = \frac{30}{1} \times \frac{\overset{5}{\cancel{100}}}{\underset{1}{\cancel{20}}}$ = 150 lbs (sulphate of amonia) (75 kg)

Reqd. Quant. of P-fert. $= \frac{45}{50/100} = 45 \times \frac{\overset{2}{\cancel{100}}}{\underset{1}{\cancel{50}}}$ = 90 lbs (super-phosphate) (45 kg.)

Reqd. Quant. of K-fert. $= \frac{60}{60/100} = \overset{1}{\cancel{60}} \times \frac{100}{\underset{1}{\cancel{60}}}$ = 100 lbs (muriate of potash) (50 kg.)

To form the mixture, the grower would need to add -

$$\left.\begin{array}{l}\text{150 lbs sulphate of amonia}\\ \text{+ 90 lbs super-phosphate}\\ \text{+ loo lbs muriate of potash}\end{array}\right\}\begin{array}{l}\text{equivalent of NPK/10-15-20 at 3 hbs / acre.}\\ \text{or approx. 300 kg. / ha.}\end{array}$$

<u>How general fertilizer recommendations are made.</u>

General recommendations of fertilizers for a crop on a soil is made from two main considerations.

1. The level of plant element requirement of the crop (i.e. level of each major element)

2. The level of plant elements in the soil. (i.e. level of each major element in the soil)

The fertilizer application which is likely to produce the best production is most likely to give the best economic returns to the farmer.

We must bear in mind that the crop requirement will be met from the nutrients in the soil and the fertilizer nutrients applies to the soil. In other words, Soil NPK + fert. NPK → Crop NPK

Levels of plant element requirement. - Crop (E)

Different crops require different quantities of each element for maximum growth and food production. These requirements can be expressed as percentages (or weights) of each element absorbed when grown under average field conditions. This has to be determined by growing the crops with adequate water, fertilizer and other requirements, then analysing the entire crop when matured to find the amounts of plant nutrients presents. Such experiments have to be carried out by specialists who have the knowledge and equipment to do such work.

To find the requirement, the amount of each element in a given quantity of the crop is compared, in addition to comparing these with the amount for other crops reaped from a given area of land. The results are obtained from doing fertilizer trials with each crop on different soil types and analysing the N,P,K make up of the plant material.

(Now, the average amount of each primary nutrient absorbed by a crop can be used in determining levels of each element required by the crop. This will later be used as a guide to recommend different fertilizer grades).

(10:7)

Absorption of N,P and K by Crops.

	Lbs N,P & K in 1000 lbs plant Material			
CROPS	N	P	K	Total
Beans	3.7	0.9	4.4	9.0
Beet	4.6	0.6	4.1	9.3
Brocolli	5.0	1.7	4.2	10.9
Cabbage	2.9	0.8	2.9	6.6
Carrot	3.4	0.7	4.3	8.4
Cauliflower	3.2	1.1	2.9	7.2
Celery	2.4	1.4	5.6	9.4
Collard	4.0	0.9	5.2	10.1
Corn	3.1	1.1	1.3	5.5
Cucumber	2.1	0.6	2.9	5.6
Kale	4.0	1.4	3.5	8.9
Lettuce	2.3	0.7	4.3	7.3
Muskmellon	2.8	0.9	4.8	8.5
Mustard	4.0	1.6	3.5	8.9
Okra	0.9	0.4	2.7	4.0
Onion	2.4	0.8	3.0	6.2
Parsley	1.5	0.4	1.3	3.2
Parsnip	2.9	1.0	1.6	5.5
Pea	3.7	0.7	2.2	6.6
Pepper	2.4	2.7	1.9	7.0
Potato	3.9	0.8	5.7	10.4
Pumpkin	3.9	1.0	4.5	9.4
Spinach	5.1	1.5	4.2	10.8
Squash	2.1	0.4	2.9	5.4
Tomato	3.8	1.1	6.8	11.7
Turnip	3.0	0.8	3.0	6.8

Ref: These figures are calculated from " Handbook for Vegetable Growers" - by J.E. Knott. The data is compiled from many sources and is the average of results from experiments on different soils.

Multiply figures by 0.45 to convert to kilograms.

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* Nitrogen in beans mostly absorbed from the air and not from the soil. Figure given same as pea.

Levels of total crop nutrient requirement.

The levels of total nutrient required by a crop is determined by the amount of primary nutrients in an average yield of plant material. The data is got from experiments and analysing plant material for N,P and K when each crop is grown on different soils.

The steps to arrive at the levels of each plant element and total nutrients absorbed by a crop are as follows:-

(1) Determine the average yield of plant material for each crop per acre. (The proportion of crop material reaped for food to crop remains can be determined by sampling any where from 100 to 200 plants per acre. When the weight of the food is known, the crop remains can be calculated. Alternatively, the entire crop material can be weighed from ½ to 1 sq. chain (sq. m) of the field.

(2) Determine the amount of N,P and K absorbed by the crop. Multiply total reaped by amount of each element in 1000 lbs plant material)

(3) Find total NPK absorbed by the crop.

(4) The levels of each element and total nutrients absorbed by the crop is determined by dividing the range of results into roughly equal levels.

Total NPK Absorbed by Crops.*

(10:8)

CROPS	Portion Eaten	Crop Remains	Tot. reaped. (000lb)	N (lbs per	P acre	K).	Total Crop NPK
Beans	2	8	10	37	9	44	90
Beet	10	6	16	74	10	66	150
Brocolli	6	6	12	60	20	50	130
Cabbage	12	2	14	41	12	41	90
Carrot	12	6	18	61	13	77	150
Cauliflower	6	9	15	48	17	44	118
Celery	12	2	14	34	20	78	130
Collard	8	1	9	36	8	47	90
Corn (Green)	3	9	12	37	13	20	70
Cucumber	12	6	18	38	11	52	100
Kale	6	1	7	28	10	25	60
Lettuce	10	2	12	28	8	52	90
Muskmellon	12	3	15	42	14	72	130
Mustard	8	1	9	36	14	32	80
Okra	8	12	20	18	8	54	80
Onion	12	3	15	36	12	45	90
Parsley	8	1	9	14	4	12	30
Parsnip	10	5	15	44	15	24	80
Peas	2	12	14	52	10	31	90
Pepper	4	6	10	24	27	19	70
Potato	12	8	20	78	16	114	210
Pumpkin	15	5	20	78	20	90	290
Spinach	10	2	12	61	18	50	130
Squash	10	6	16	34	7	46	90
Tomato	12	3	15	57	17	102	180
Turnip	10	5	15	45	12	45	100

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* Note that the total crop NPK is the approx. sum of N,P and K.

The levels of plant elements and total nutrients absorbed by each crop. (Figures in lbs /ac. or kg /ha).

(10:9)

Levels	Nitrogen		Phosphorous		Potassium		Total NPK	
Very low	N_{L1}	< 20	P_{L1}	< 5	K_{L1}	< 20	NPK_{L1}	< 50
Low	N_L	20 - 34	P_L	5 - 9	K_L	20 - 34	NPK_L	50 -89
Medium	N_M	35 - 50	P_M	10 - 15	K_M	35 - 50	NPK_M	90 -129
High	N_H	51 - 65	P_H	16 - 20	K_H	51 - 65	NPK_H	130 - 170
Very	N_{H1}	> 65	P_{H1}	> 20	K_{H1}	> 65	NPK_{H1}	> 170

(10:9b) Levels of plant nutrients absorbed crops.

Crops.	(Levels of elements absorbed per. ac)			
	N	P	K	NPK
Beans	M	L	M	M
Beet	H_1	M	H_1	H
Brocolli	H	H	M	H
Cabbage	M	M	M	M
Carrots	H	M	H_1	H
Cauliflower	M	H	M	M
Celery	L	H	H_1	H
Collard	M	L	M	M
Corn	M	M	L	L
Cucumber	M	M	H	M
Kale	L	M	L	L
Lettuce	L	L	M	M
Muskmellon	M	M	H_1	H
Mustard	M	M	L	L
Okra	L_1	L	L	L
Onion	M	M	M	M
Parsley	L_1	L_1	L_1	L_1
Parsnip	M	M	L	L
Peas	H	M	L	M
Pepper	L	H_1	L_1	L
Potato	H_1	H	H_1	H_1
Pumpkin	H_1	H	H_1	H_1
Spinach	H	H	M	H
Squash	L	L	M	M
Tomato	H	H	H_1	H_1
Turnip	M	M	M	M

Using the above standards, we can group crops into 3 broad categories viz:-

- High total nutrient requirement or high feeders
- Medium total nutrient requirement or medium feeders
- Low total nutrient requirement or low feeders.

(10:10) Crop Nutrient Requirements

Low feeders (Crop NPK$_L$)	Medium feeders (Crop NPK$_M$)	High feeders (Crop NPK$_H$)
	Beans	Beet
Corn	Cabbage	Brocolli
Kale	Cauliflower	Carrot
Mustard	Collard	Celery
Okra	Cucumber	Muskmellon
Pepper	Lettuce	Potato
Parsley	Onion	Pumpkin
Parsnip	Pea	Spinach
Radish	Squash	Tomato
	Turnip.	
	* Brussels sprout, * calaloo, *Chard,*Kohlrabi,* Leek and * Escallion can be included based on response to fertilizers.	* Egg-plant, * Watermellon

* Later, we will see how the crop requirement of each primary element and the total requirements can be used in making fertilizer recommendations.

Recommending fertilizer grades.

The levels of N,P and K absorbed by a crop, as mentioned before, is useful in making fertilizer recommendations, Instead of making specific recommendations, we can recommend levels of grades and rates that the vegetable grower can start with, later adjusting these to improve production on the farm.

(10:11) Here are the levels for each element in a fertilizer.

Very low E_{L1} - below 5% of the element
Low (E_{L}) - 5 to 10% of the element
Medium (E_{M}) - between 10 - 14% of the element
High (E_{H}) - 15% to 20% of the element
Very High (E_{H1}) - over 20% of the element

The upper limit of the E_{H1} level is determined by the levels of the other elements in the mixture. Remember that in a NPK fertilizer, the sum of the percentages cannot be over 100.

These limits are set to avoid confusion. A grower can buy fertilizer with the element as 10% for low and 15% for medium. He could not go over these limits.

Example 1.
The levels of NPK /10-10-10 fertilizer can be expressed

as N_M - P_M - K_M
(or NPK/ M-M-M)

Example 2.
The levels of a NPK/5-10-20 fertilizer can be expressed

as N_L - P_M - K_H
(or NPK/ L-M-H)

Using the method.

Here is how this method of expressing levels of plant elements in a fertilizer can be used.
Example: The general. recommended fertilizer for growing beans on certain soils is - $N_M - P_H - K_M$

This means that a number of fertilizers can be used.eg.

NPK/ 10 - 15 - 10
or 11 - 15 - 10
or 11 - 16 - 10
or 11 - 16 - 11
or NPK / 12 - 16 - 11
up to NPK / 14 - 19 - 14

The percentages within each level when used later with rates of application are calculated to satisfy the crop nutrient requirements. Based on the function of each primary element in the plant, very rough levels of grades can be recommended according to the part of the crop eaten.

For leafy vegetables	use $N_H - P_M - K_M$	or NPK/M-M-M
For tubers and root vegetables	use $N_M - P_M - K_H$	
For Fruit Vegetables	use $N_M - P_H - K_M$	

This method is only a rough guide, since it does not consider the plant element requirement of each crop.

In Table (10:12), the recommended levels of N, P and K given are based mainly on the levels of N, P and K absorbed by each crop. The grades will have to be adjusted according to the level of each element in the soil. This will be done for each crop in the next section. (See Part 3)

Recommended fertilizer rates -

While the recommended level of each primary element is based mainly on the levels of each absorbed by the plant, the recommended levels of amount to apply are based mainly on the total nutrient requirement of the crop. (Fertilizer grades and rates together determine the amount of nutrients in the chemical and are both used here). Two other major factors which have to be considered in recommending the levels of rates to apply are:-

(a) The levels of total nutrients or total nutrient status of the soil ie Soil NPK_L, Soil NPK_M, Soil NPK_H.
The level of total nutrients is the sum of the level of each plant element in the soil. (See note on next page)

(b) Levels of plant population which also affects the crop nutrient requirement.
ie. $Pop^n{}_L$, $Pop^n{}_M$, $Pop^n{}_H$.

The levels of each primary element, the total nutrient status and population levels will later be used when recommending grades and rates for the different crop under such conditions. For the time being, the table below can be a useful guide. These rates are based on usual recommendations given for high economic returns to farmers in the tropical countries. The rates recommended assume a medium supply of N,P, & K, and plant population, considers economic factors and is based on a simple standard:-

(10:11)

Crop NPK	Rate NPK	Levels	Average
Very low feeder	Very low	0 - 2	200
Low feeder	Low	2 - 4	300
Meidum feeder	Medium	3 - 5	400
High feeder	High	4 - 6	500
Very high feeder	Very High	5 - 7	600

(lbs/ac or kg/ha)

Note

Based on results of soil tests the overall nutrient status like that of individual elements can be determined. But where one knows the levels of each primary element in the soil, it is easy to get a good idea of what the total nutrient level is. Here is a convenient standard, which can be used for of N,P and K in soil and absorbed by a crop.

Very low total nutrients (NPK_{L1}) - more than 1 element in very low quantity but none high.

Low total nutrients (NPK_L) - more than one element in low quantity in the soil (in available form) eg. $N_L - P_L K_L$, $N_L - P_M - K_L$, $N_L - P_L - K_H$.

Medium total nutrients (NPK_M) - more than one element in medium,but not more than one in high quanitty in the soil (in available form.) eg. $N_M - P_M - K_M$, $N_M - P_M - K_L$, $N_L - P_M - K_H$.

High total nutrients (NPK_H) - more than one element in high quantity in the soil (in available form.) eg. $N_H - P_H - K_H$, $N_H - P_M - K_H$, $N_H - P_L - K_H$

Very high total nutrients (NPK_{H1}) - more than 1 element in very high quantity, but none low.

(10:12) General Fertilizer Recommendations

The fertilizer recommendations below are based on the levels of N, P and K absorbed by the crops and given in the previous table. The fertilizers to be applied will supply more than the nutrients removed from the soil. It is assumed that all elements are in medium supply in the soil and a medium population of the crop is to be grown. Some adjustments are made in the levels to insure that leafy vegetables get adequate N, fruit and grain crops get adequate P and root crops adequate K.

Fert. Recom. (lbs / ac or kg / ha)		
NPK Levels	Example	Crops
M-M-M at M	12 - 12 - 12 at 400	Beans
H-M-H_1 at H	16 - 12 - 20 at 500	Beet
H-H-M at H	16 - 16 - 12 at 500	Brocolli
M-M-M at M	12 - 12 - 12 at 400	Cabbage
H-M-H_1 at H	16 - 12 - 20 at 500	Carrots
M-H-M at M	12 - 16 - 12 at 400	Cauliflower
M-H-H at H	12 - 16 - 16 at 500	Celery
M-L-M at M	12 - 8 - 12 at 400	Collard
M-M-L at L	12 - 12 - 8 at 300	Corn
M-M-H at M	12 - 12 - 16 at 400	Cucumber
M-M-L at L	12 - 12 - 8 at 300	Kale
M-L-M at M	12 - 8 12 at 400	Lettuce
M-M-H at H	12 - 12 - 16 at 500	Muskmellon
M-M-L at L	12 - 12 - 8 at 300	Mustard
L-M-L at L	8 - 12 - 8 at 300	Okra
M-M-M at M	12 - 12 - 12 at 400	Onion
M-L-L at L_1	12 - 8 - 8 at 200	Parsley
M-M-M at L	12 - 12 - 12 at 300	Parsnip
M-M-L at M	12 - 12 - 8 at 400	Peas
L-H_1-L at L	8 - 20 - 8 at 300	Pepper
H-H-H_1 at H_1	16 - 16 - 20 at 600	Potato
H-H-H at H_1	16 - 16 - 16 at 600	Pumpkin

Cont'd...

H-H-M at H	16 - 16 - 12 at 500	Spinach
L-M-M at M	8 - 12 - 12 at 400	Squash
H-H-H at H_1	16 - 16 - 16 at 600	Tomato
M-M-M at M	12 - 12 - 12 at 400	Turnip
These recommendations are very general:-		
	16 - 12 - 12 at 400	Brussels Sprout
	16 - 12 - 12 at 400	Calaloo
	16 - 12 - 12 at 400	Chard
	12 - 12 - 12 at 400	Kohlrabi
	12 - 12 - 16 at 400	Leek
	12 - 12 - 12 at 400	Escallion
	8 - 8 - 8 at 200	Ladish
	12 - 16 - 12 at 500	Egg-plant
	12 - 12 - 16 at 500	Watermellon
	12 - 12 - 12 at 400	Rutabaga

The recommendations given in Table (10:12) uses a medium plant population and assumes that the soil has a medium supply of N,P and K. Because of the crop requirement, the grower should try to maintain this level of available nutrients to get good yields. Where the level of available nutrients in the soil is known, both the grade and rate of applying fertilizers would have to be adjusted to satisfy the needs of the crop grown.

Remember that it is the level of each primary nutrient which is used for recommending the fertilizer grades, while it is the total nutrient status which is used to recommend the rates of application. It is always best to start with a rate of fertilizer application and a population level which is the same as the total nutrient level of the soil. Then the rates of fertilizer application and fertilizer grades can be adjusted in later crops as the grower sees it necessary to get better returns from his crop.

When we come to recommending grades for each crop, the general recommendation will be given and the changes can be made as follows:-

(10:13a)
- when the level of an element in the soil is very low, add 10% of that element to the general recommendation
- When the level of an element is low, add 5%
- When the level is high, subtract 5%
- When the level is very high, subtract 10%of that element from the generally recommended grade for the crop.

The rates will be recommended based on the table below.

(10:13b) The rates are in hbs/acre (or oo kg/ha

Soil	Low feeders			Medium feeders			High feeders		
NPK	Pop$_L$	Pop$_M$	Pop$_H$	Pop$_L$	Pop$_M$	Pop$_H$	Pop$_L$	Pop$_M$	Pop$_H$
NPK$_L$	2	3	4	5	6	7	8	9	10
NPK$_M$	1	2	3	3	4	5	5	6	7
*NPK$_H$	0	1	2	2	3	4	4	5	6

Example:

A soil test or a soil survey map indicates that the nutrient levels on a farm are:-

N - low ; P - high ; K - low

Soil NPK would therefore be low.

The farmer plans to grow a crop of kidney beans.
What fertilizer recommendation should he use?

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* (Most of the fertilizer recommended for soil NPK$_H$, would be mainly to supply the element which is deficient in the soil)

The general recommendation for beans is $N_M - P_M - K_M$ at 300 - 500 lbs per acre or 300 - 500 Kg/ha (Table 10: 12). For the above soil, the fertilizer grade that should be used for a start would be N_H - P_L - K_L. He may start with a low population say 50,000 plants per acre, and apply a 16 - 8 - 8 fertilizer at 500 lbs per acre or 500 Kg/ha. (Table 10:13b)

Calculating fertilizer recommendations

It is possible to calculate fertilizer recommendations which can be used as a starting point for experimenting with fertilizer grades and rates. This is strictly for more advanced students and the resulting recommendations will not consider economic factors which is so important to the farmer. In other words,these recommendations may give very high yields, but sometimes because of the quantity of fertilizer which are required, it is not profitable for farmers to use these calculated recommendations .

But students can calculate these recommendations, use lower and higher amounts of N,P and K, see the productions, then try to work out some costs and returns to see which fertilizer grade gives the highest economic returns.

This approach is based on the principle
Fertilizer NPK = Crop Npk - Soil NPK.

For example, the amount of N which has to be applied depends on the amount required by the crop and the amount which is available from the soil.

The recommendations are worked out from finding the weight of each element (E_W) to be applied, but can be converted to grades and rates (GR) of application. So we need to know the following:-

1. - The requirement of N, P and K by the crop to be grown.
2. - The quantity of N,P and K in the soil
3. - The amount of this N, P and K that the crop is likely to absorb from the soil, and;
4. - The amount of N, P and K which the crop is likely to obtain from fertilizers.

The requirement or the amount of N,P and K absorbed by the crop can be found by first knowing the amount of N, P and K in a given weight of the plant material and secondly, the expected yield of plant material from the crop.

Step 1. The amount of N, P and K in a given weight of plant material, has to be determined by analysing this material in a laboratory. Tab e (10:7) gives some figures, which can be used as a standard for this exercise.

Step 2. The yield of crop material has to be estimated from finding out the average ratio of the portion of the crop eaten to the remaining portion of the crop. This can be found by getting a sample of not less than 10 mature plants per square chain, taken from different parts of the field.

Weigh the portion which is reaped for food, then weigh the remain of the crop. Now, when we know the proportion of part-eaten to remains, and we know what yield of edible material a good crop produces, the total yield of crop material can be found.

(The plant population can also be used, because if say, 10 plants weigh 5 pounds, then a population of 10,000 plants would weigh 5000 lbs).

Step 3. Now the total amount which the crop is likely to absorb, is determined by multiplying the amount of N,P and K in a given weight of the crop material by the yield of plant material.

Step 4. The amount of N,P and K in the soil can also be roughly calculated.

The result of soil tests, which shows the proportion of N,P and K in a given weight of the sample and the estimated weight of an acre-furrow of soil can be used.

The proportion of soil N,P and K is given in percentages or parts per million (ppm). The weight of an acre furrow was discussed in Chapter , and the standard of 2 million pounds can be used.

Step 5. The amount of each primary element the crop is likely to take from what is available in the soil, has to be determined by deep analysis and research.

From various studies, it seems that most vegetable crops take about 2% of N, 1% of P and 3% of K from that available in the soil. But crops with a more extensive root system may take up to 4% N, 2% P and 5% K.

Step 6. The amount of each element the crop is likely to take up from the fertilizer applied also needs deep experimentation. Here, it seems that the crop can take up as much as about 65% of the N, 20% of P and 50% K. This helps to determine the amount of fertilizer which has to be applied. To understand this whole exercise, let us look at an example.

Example.

A student wants to find a fertilizer recommendation which he can use as a basis for experiments with carrot.

Step 1. Crop absorb approximately 3.4 lbs N per 1000 lbs of crop Material.
" " approximately 0.7 lbs P " " " "
" " approximately 4.3 lbs K " " " "
(See Table 10:9)

Step 2. Weight of sample of 10 carrot plants yield
approximately 2 1/2 lbs roots. and;
app. 1 lb top.
Proportion of roots : tops = 5: 2
Proportion of roots to total plant material = 5/7
Good crop of carrot in area produces app. 5 tons per acre (roots).

Total crop material = 10,000 x 7/5 lbs
app. 14, 000 lbs

Step 3. Total crop requirement of N approximately 3.4 x 14 app 48 lbs
" " " of P app. 0.7 x 14 app 10 lbs
" " " of K app. 4.3 x 14 app 58 lbs

Step 4. Result of soil test shows :-
proportion of available N = 0.15 %
" " " P = 50 ppm
" " " K = 120 ppm.

Amt. of available N app. $\frac{0.15}{100} \times 2000,000$ app. 3,000 lbs

Amt of available P app. $\frac{50}{100} \times 2,000,000$ app. 100* lbs

(* 50 parts per million = 50 lbs per 1 million pounds)
= 50 x 2 lbs in 2 million pounds.)

Amt. of available K app. 120 x 2 app. 240 lbs.

Step 5. Amt. of N soil likely to supply app. $\frac{2}{100} \times 3000$ app. 60 lbs

Amt of P soil likely to supply app $\frac{1}{100} \times 100$ app. 1 lb.

Amt. of K soil likely to supply app. $\frac{3}{100} \times 240$ app. 7 lbs.

Step 6. Amt. of N reqd from fertilizer app None.
The soil should supply 60 lbs, which is more than the 48 lbs required by the crop of carrots.

Amt. of P reqd from fertilizer = 10 - 1 = 9 lbs
Amt. of P to be applied = $9 \times \frac{100}{20}$ = 45 lbs

Amt. of K reqd from fertilizer = 58 -7 = 51 lbs
Amt. of K to be applied = $51 \times \frac{100}{65}$ = 72 lbs

Calculated recommendations are:-

Amt. of N to be applied: None
Amt. of P to be applied: 60 lbs
Amt. of K to be applied: 90 lbs

Recommended single fertilizers
Nitrogen = None
Single Super-phosphate (20%P) = 45 x $\frac{100}{20}$ = 225 lbs per acre
Muriate of potash = 92 x $\frac{100}{60}$ = 120 lbs per acre

Recommended complete fertilizers
NPK/0 - 24 -12 at 10 hbs/acre

(A NPK / 5 - 20 - 10 at 10hbs per acre should give better results since it is always good to apply a small amount of N in fertilizer which is readily available and very helpful to the crop in the early stages).

E. HOW TO APPLY FERTILIZERS

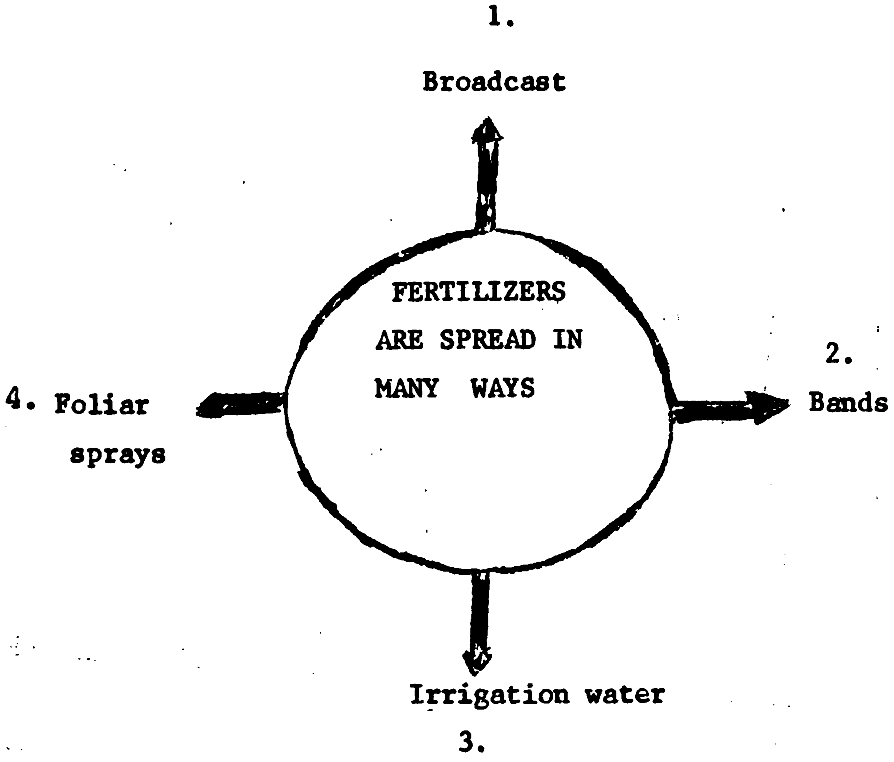
In applying the required fertilizer, there are 2 factors the vegetable grower has to decide on - viz.

Method of spreading the fertilizer
Number of applications.

Method of spreading fertilizer.

Fertilizers are usually spread in one of 4 ways viz.

1. Applying in broadcasts) Solid
2. Applying in bands.) fertilizer
3. Applying in irrigation water) Liquid
4. Applying in foliar sprays.) fertilizer.



(10:14) (i) Methods of spreading fertilizer

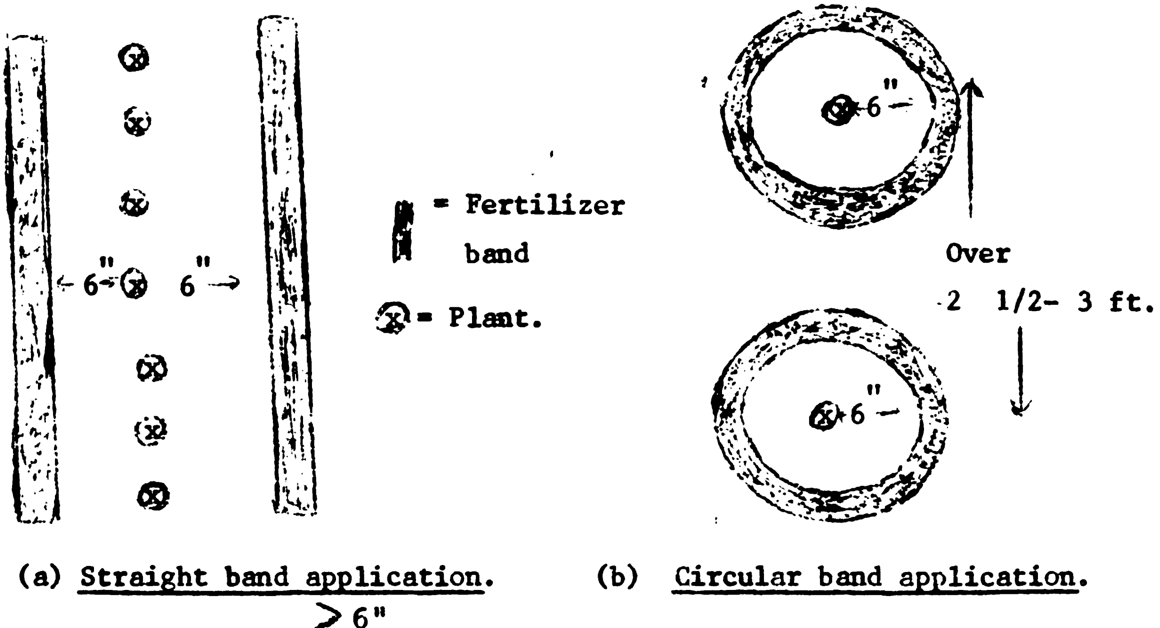
(1) Broadcast - In broadcasting fertilizers, the required quantity is scattered over the whole field. This can be done by -

i . Walking through the field and scattering the material from a container. A bucket or any open container can be carried and fertilizer distributed in handfulls.

ii. It can be carried in a wheel burrow with one person pushing and another using a spade to scatter the material.

iii. Using a fertilizer spreader made for broadcasting the material. This may be a small one carried and operated by a farmer or a big spreader drawn and operated by a tractor.

(2). Bands - In this method, the required quantity of fertilizer is applied in bands either on both sides of the plant (straight bands) or in a circle around the plant (circular band). The band might be anywhere between 3-9 ins. wide.



(10:15) (a) Straight band application. (b) Circular band application.

The bands are usually placed >6" away from the plant. If the fertilizer is nearer the concentration might be too great when it dissolves and will burn or kill the plant when absorbed. Circular band application is usually done by hand while the straight band can be done both by hand and by use of a fertilizer spreader.

Sometimes a broad single band of fertilizer is put between the rows when the rows are not too far apart (1 1/2 - 2 1/2 ft or 45 - 75 cm). If inter-row ploughing is done soon after, the material is well worked into the soil.

3. Irrigation water - In this method, the required quantity of fertilizer is dissolved in the water used to irrigate the field at set intervals. It can be used with both furrow and over-head irrigation. There are specially made fertilizers for this purpose, but if these are not available, other fertilizers can be used. suggested ways to apply the materials in irrigation water are given below*

4. Foliar sprays - In this method the required amount of fertilizer material is dissolved in water and sprayed on to the foliage of the crop. It is used mainly for correcting deficiency of secondary and trace elements as the quantity of material used is usually small. The solution is sprayed on the plant like insectcide or fungicide.

   The rate of applying the solution is also the same and the same equipment can be used. In some cases, foliar spray can be applied with insectcides or fungicides, but if the grower does not know for sure if the two types of chemicals are compatible, he should apply them separately.

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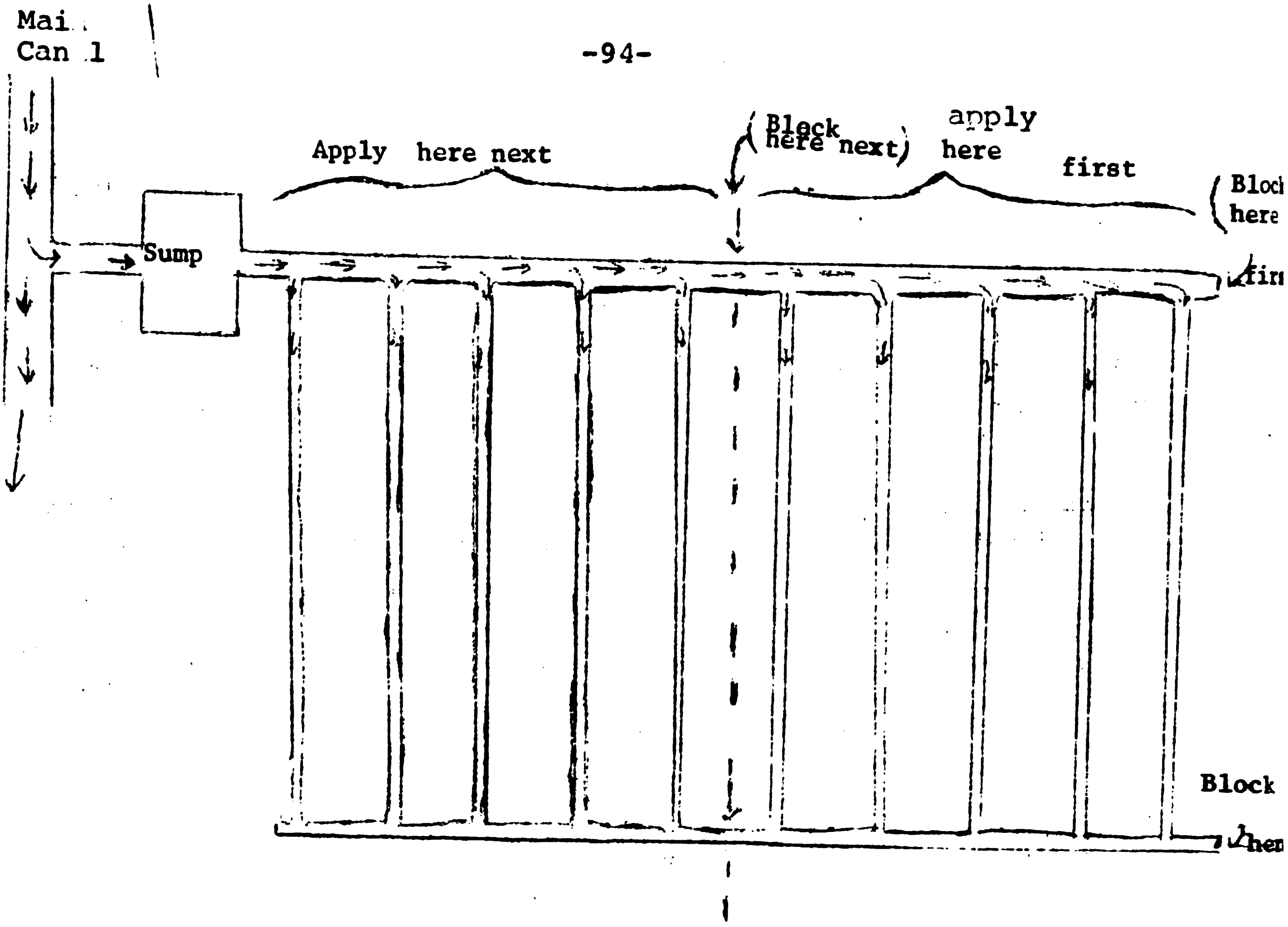
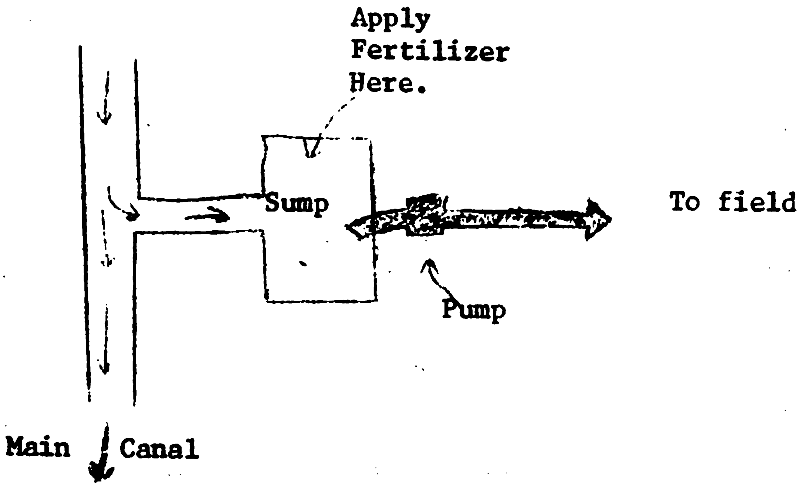
*1. Set the material to dissolve in 1-2 large drums before application. The length of time is to be set before it is needed will depend on the solubility of the material i.e. the more soluble the fertilizer the less time is required. At irrigation the mixture will be added to the sump. During application, the solution is properly mixed in the irrigation water by stirring the sump every half-hour

2. After each application, pure water should be run through irrigation pipes for about 1/2 hour to wash out the equipment since the fertilizer solution will corrode the metal. This also washes the fertilizer off the leaves.



(10: 17) (a) Applying fertilizer in furrow irrigation.



(10: 16) (b) Applying fertilizer in overhead irrigation.

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* Arrows indicate the direction in which the water is flowing.

Solubility of fertilizers.

The solubility of a fertilizer refers to how much of that material will dissolve in a given quantity of water.

How easily a fertilizer will dissolve is important in choosing fertilizers for starter solutions, foliar sprays and fertilizers to be applied in irrigation water.

Here is a list of some commonly used fertilizers. They are listed according to how soluble they are. i.e. most easily dissolved first,to least soluble last.

(10:18)

Fertilizer material and elements supplied		Approx. part soluble in 100 parts cold water
Amonium nitrate	(N)	118
Manganese sulphate	(Mn and S)	105
Calcium nitrate	(Ca and N)	102
Urea	(N)	78
Zinc sulphate	(Zn and S)	75
Sodium nitrate	(N)	73
Sulphate of ammonia	(N)	71
Magnesium sulphate	(Mg and S)	71
Calcium chloride	(Ca)	60
Borax	(B)	60
Sodium molybdate	(Mo)	56
Diammonium phosphate	(P)	43
Ferrous sulphate	(Fe and S)	29
Mono -ammonium phosphate	(P)	23
Copper sulphate	(Cu and S)	22
Potassium nitrate	(K and N)	13
Triple Super-phosphate	(P)	4
Single super-phosphate	(P)	2
Copper oxide	(Cu)	not soluble

Fertilizer materials that have a solubility of less than 20 are not easily applied in solution. The best way however to check this is to see how a small quantity of the material dissolves in a small amount of water. (eg. 1/4 lb in 2 galls. water).

Liquid Phospheric acid (approx 50%P)

Solid fertilizer materials high in phospharous,are usually difficult to dissolve. P can be supplied in solution by liquid phospheric acid

For applying 50 lbs P per acre use approx 7.5 gallons P-acid.
For applying 100 lbs P per acre, use approx 15 gallons P-acid.
For applying 150 lbs P per acre, use approx. 22.5 gallons P-acid.
or approx 150 Kilos per ha, use approx 90 litres P-acid.

To detm. reqd. P Per. Unit Area.

1. Find the recommended fertilizer rate and analysis for the crop.
2. Multiply the % P in the fertilizer by the rate per acre. This gives the required P per acre.

Example

NPK/10-15-10 at 4 hbs / acre is recommended for a crop. The required amount of P

= 15 x 4 = 60 lbs / acre (60 kg/ha)
8 - 9 gallons of P - acid could be used. (30 - 34 litres)

Starter solutions

The vegetable grower will find that if he applies weak solutions of NPK fertilizer to his nursery, it will increase the vigour of his young plants and reduce the time taken for them to be ready for transplanting.

Recommendation - 1.A suitable solution might contain approx. 8 ozs in 5 galls water of fertilizer with 30 - 35% NPK
Or 2. Approx. 6 ozs in 5 galls. water of fertilizer with 35 - 45% NPK
Or 3. Approx 5 lbs 35-45% NPK in solution per acre.
Or 4. Approx 5 kg 35 - 45% NPK in solution per hectare.

Fertilizer spreaders.

These are equipments specially made for applying fertilizers. There are the small types that are either carried by the individual in broadcasting (eg. cyclone) or pushed along the row and it applies the material in bands.

Then there are the larger ones that have to be drawn by a tractor. Those that can broadcast the material can also be used for applying material for correcting soil acidity. But it is more advisable for the vegetable farmer to buy the type that can apply the material in bands.

The reason is that most times, it is safer to apply the fertilizer in bands after the crop has started growing, since some fertilizers (particularly acid fertilizers) will damage most crops if allowed to touch the leaves. Most peasants growing vegetables cannot afford large spreaders except it is bought in a co-operative venture.

(10:19) (i) Cyclone (ii) Planet-Jnr Spreader (iii) Large fertilizer spreader.

Which method to use.

The method used to spread the fertilizer material will depend mainly on:-

1. The crop to be fertilized.
2. The soil and climate conditions.
3. Rate of application
4. Type of equip ment available to spread the material.

Let us get one thing out of the way viz. foliar application is used almost only for correcting hunger in secondary and trace elements. This is primarily because the rate applied is usually so small that soil application is very difficult. When to use irrigation water for applying fertilizer will be discussed in a minute, so that our immediate concern is when to apply by broadcasting and in bands.

While in some cases one of these methods is used throughout a crop, more often both are used at different times.

Broadcasting - This is the easiest method and also the least expensive. It is often used for adding fertilizer at planting to crops which are planted at shorter distances (1 1/2 - 2 1/2 ft. or 45 - 75 cm) between the rows. Because the young plant does not have a well developed root system, the fertilizer material should be near to the roots. (but not too near to damage it). So even at planting, broadcasting is not ideal.

When certain crops have grown to some extent, broadcasting can be used in later applications (top dressing). This has to be firstly, crops that are not planted too far apart. (Not as important as application at planting). Secondly, leaf arrangement of the crop should be such that the fertilizer material is not held between the leaves at application. (eg. corn or cabbage). Later when the field is irrigated, the fertilizer might damage or kill the plants. This is important particularly when acidic materials are used. However, when the crop has grown to some height (eg. corn, beans or tomato,) if the fertilizer is spread by hand, it can be applied low to avoid particularly the younger leaves.

(10:20) (a) Broadcasting fertilizer. (b) Band application of fertilizer

Applying in bands - This seems to be the method that can be most safely applied, however, it takes the most time and might not be the most profitable method for the vegetable farmer.

At planting, band application should be used for most crops. The fertilizer material should be scattered in the furrow. Some soil should be pushed over the fertilizer in the bottom of the furrow to prevent the seed actually touching the material. It is sometimes recommended that the band should be 2 ins below and 2 ins to one or both sides of the seed. This might be a good recommendation for students doing experiments and for big farmers using special planting and fertilizing equipment. But the small vegetable farmer who has to consider labour costs will do well to think twice before he sticks to such suggestions.

In later applications (side-dressing), if the distance between plants along the row is greater than 21/2 - 3 ft. the circular band method should be used. Otherwise the material should be applied in straight bands. When possible, the machinery available should be used for all spreading of fertilizer.

Irrigation water - Fertilizer materials can be applied in irrigation water when -

(i) the irrigation water is available ,
(ii) the material can be easily dissolved,
(iii) the texture of the soil and slope of the land will not cause the material to be easily washed away.

This method can be quite profitable if properly used. This is mainly because it reduces labour cost of application to a minimum as application will be done at the same time that the field is being irrigated.

Because the fertilizer will be applied in solution, it will be almost immediately available to the plant. In addition, the nutrients can more easily be removed from the field as excess irrigation water is drained off. This is particularly true of soil with rapid drainage and sloping land generally. There are two ways to fight this.

1. Implement special measures to reduce drainage when fertilizer is applied. (eg. do not open furrows and drains)

2. Apply the fertilizer material more regularly at a slightly increased rate if necessary i.e. apply the required quantity at about every 2 weeks.

   The rate of application should be divided by the number of applications and that quantity applied each time. The number of applications would depend on - duration of crop and frequency of application.

Example.

5 hbs of fertilizer is to be applied at 2 weeks interval to a crop of 12 weeks duration.

$$\text{Number of application} = \frac{\text{duration of crop}}{\text{frequency of application}} = \frac{12}{2} = 6 \text{ applications}$$

(one at planting with the 6th on the 10th week)

$$\text{Amount at each application} = \frac{\text{Rate of application}}{\text{No. of application}} = \frac{500 \text{ lbs}}{6} = \text{approx. } 80 \text{ lbs}$$

In this case 100 lbs could be used. This would make the rate 100 lbs/acre <u>or</u> 100 kg/ha above recomm. rate using solid material.

It is best to wet half the field first and then the other half later. This will allow for a better distribution of the fertilizer when using furrow irrigation. With overhead irrigation, if for instance the equipment can wet only 1/2 acre at a time, 1/2 the quantity should be applied also in wetting each section. Applying the fertilizer in the first half of the time allow for the rest of time to be used to apply pure water for washing the material off the foliage and out of the equipment.

<u>The vegetable grower should use his own initiative and find ways that will make the method work for him.</u>

Number of applications and quantities to apply.*

The number of times fertilizer will be applied and the amount at each time will depend largely on the crop to be grown and the soil type on which it is grown.

The vegetable farmer has to decide on the number of applications to make from the point of view of how these will affect yields and total expenses.

Here are some suggested numbers of application and quantities for crops of different durations.

SHORT (duration) Crops = (less than 12 wks. duration)
MEDIUM (duration) Crops = (over 12 weeks to 4 mths. duration)
LONG (duration) Crops = (over 4 mths up to 6 mths. duration)

(10:21)

	CLAY AND LOAMS						SANDY SOILS					
Crop duration	No. of appl^{n}	1st.	2nd.	3rd.	4th	5th	No. of appl^{n}.	1st	2nd	3rd	4th	5th
SHORT	2	1/3	2/3				3	1/4	1/2	1/4		
MEDIUM	3	1/4	1/2	1/4			4	1/5	2/5	1/5	1/5	
LONG	4	1/5	2/5	1/5	1/5		5	1/6	1/6	1/3	1/6	1/6

(* The above information does not hold for slow release fertilizers. ie. fertilizers specially made for releasing nutrients over a long period. It also does not hold if fertilizer is applied in irrigation.)

The times at which each application should be made will be given for each crop in sect. 5. Generally the 2nd and 3rd applications should be made at the periods of most rapid growth.

The fractions given in the boxes are the recommended quantities

Example.

A farmer growing cabbage (medium duration) on a clay loam with 400 lbs of NPK fertilizer, would need to make 3 applications. He would have to apply 100 lbs

(1/4 R) at planting, 200 lbs (1/2 R) in the 2nd application and 100 lbs in the 3rd application.

To get a fairly even distribution of the fertilizer, we can use basically the same method used when lime or manure is to be applied by hand. The idea is to divide the field into blocks, roughly 1 square chain (or 400 sq. m) at a time, and apply the required amount to that area. If the rate of application is to be 500 lbs per acre (500 kg/ha); we would need to apply 1/2 of a 100 lb bag to each sq. chn. (or 50 kg/400 sq. m) of the land. This can be used for most of not all methods of application we have dealt with before.

What to do after applying fertilizer.

Apply water to the field.
This is most important in that if the solid material is not in solution, the crop cannot absorb it. If irrigation water is limited, fertilizer should be applied just before rainfall is expected. This does not apply to period of heavy rain. soon we deal with growing vegetables from seasonal rainfall,

Water should be applied not only to dissolve the material, but to form a week solution that will not damage the crop when the solution is absorbed. Measures should be taken to keep the water in the field. The best thing is to do inter-row ploughing just after application and before irrigation. The dissolved fertilizer sinks most easily in the soil then.

Over-fertilizing - This is a practice that is damaging to crops and rather uneconomical. A grower who finds out that he over-fertilized his field must immediately irrigate his field for 2 - 3 hours longer than normal. This is the easiest way to save the crop.

Important points in handling fertilizers.

1. Most fertilizer materials are corrosive (wear away) particularly to metals. Therefore after application, the container s, spades etc. used, should be washed.

2. Most fertilizers particularly acid fertilizers will damage delicate parts of the body. They should not be allowed to enter the body.

3. Most fertilizers will absorb water if left in the open. If in paper bags, these bags might tear easily. If in crocus bags, the fertilizer usually cause the bag to rot. This might create problems in transporting the material to the field. Except in special cases (eg. for appl^{n} in irrigation water), fertilizers should be stored in a cool dry place.

Organic manures vs Fertilizers.

Both organic manures and fertilizers supply nutrients to vegetable crops. But there are two important differences.

1. Organic manures contain relatively small quantities of plant nutrients compared to fertilizers. For example, a ton of dried fowl manure (a high nutrient supply manure) contain approx. 150 lbs primary nutrients. On the other hand, a ton of /10-10-10 fertilizer contains approx. 600 lbs nutrients (1 tonne contains approx. 325 kg of nutrients).

Here is a further comparison:-

1000 lbs organic manure (500kg) vs 100 lbs NPK/10-10-10 (50 Kg).

	(approx wt.)		(approx.	wt.
Poultry -	11 lbs N	(5.5 Kg)	10 lbs N	(5 Kg)
	9 lbs P	(4.5 Kg)	10 lbs P	(5 Kg)
	5 lbs K	(2.5 Kg)	10 lbs K	(5 Kg)
Cow -	5 1/2lbs N	(2.7 Kg)	10 lbs N	(5 Kg)
	1 1/2lbs P	(0.7 Kg)	10 lbs P	(5 Kg)
	5 lbs K	(2.5 Kg)	10 lbs K	(5 Kg)

Quantities of manures and fertilizers used together.

If manure and fertilizers are to be used in growing a crop, the recommended rate of application for the fertilizer can be reduced as follows:-

(10:23)

Tons of manure per acre, or tonne/ha		Reduce the rate of fert application by -
0 to 5	(0 - 12)	0
5 to 10	(13 - 25)	1/4
10 to 20	(26 - 50)	1/2

Organic manures are important chiefly for improving the physical condition of the soil and not the nutrient status. Fertilizers are mainly for supplying nutrients and not for improving physical condition of soil.

2. Organic manures release their nutrients much more slowly than fertilizers. This is because the manure takes a longer time than the fertilizer to break down hence releasing its nutrients.

From looking at the major differences, we see that organic manures have the advantage in improving soil condition, while fertilizers are better for supplying nutrients. But the amount of nutrients the crop absorb depends both on the total of such nutrients in the soil and the physical condition of such soil. From this we can see that organic manure and fertilizers work together in producing a better crop. The vegetable grower should apply both separate <u>or</u> together when available.

F. FUNCTION OF PLANT ELEMENTS AND HOW TO IDENTIFY AND CORRECT NUTRIENT HUNGER.

FUNCTION OF PLANT ELEMENTS

Primary

Plant elements (N, P and K) - required in largest quantities by plants

(10:24)Nitrogen (N)

1. Gives foliage dark green colour needed for food manufacture.
2. Promotes rapid growth
3. Improves quality of leafy crops.

Phosphorous (P)

1. Helps root formation of young plant.
2. Important in flowering and seed formation.
3. Speed up maturity of fruits.

Potassium (K)

1. Helps the plant to absorb water.
2. Helps to increase vigour and resistance to diseases.
3. Helps in the development of root system.

Secondary

Plant elements (Ca, Mg and S) - required in smaller quantities.

Calcium (Ca)

1. Neutralizes poisnous substances produced in the plant.
2. Helps in the uptake of other nutrients.
3. Encourages early formation of roots and rapid growth.

Magnesium (Mg)

1. Helps to give foliage dark green colour.
2. Acts as a carrier of phosphorous in the plant.

Sulphur (S)

1. Helps maintain dark colour of foliage
2. Encourages rapid root growth.
3. Helps in seed production.
4. Promotes formation of nodules on roots of legumes. These swellings contain nitrogen.

Minor or trace elements (B, Cu, Fe)
(Mn, Mg, Zn) - required in minute quantities.

Boron (B)

1. Increases quantity and improves quality of yield.
2. Helps plant to absorb calcium.

Copper (Cu) and Iron (Fe)

1. Helps to give foliage dark green colour.

Manganese (Mn)

1. Helps to give foliage dark green colour
2. Increases speed of germination and maturity of the crop.
3. Helps the plant to absorb phosphorous, calcium and magnesium.

Molybdenum (Mo)

1. Helps the crop to absorb nitrogen

Zinc (Zn)

1. Helps to give foliage dark green colour.
2. Necessary for normal growth and production.

IDENTIFYING NUTRIENT HUNGER

Each vegetable crop requires a certain quantity of each plant element for it to grow and produce well. If an element is in short supply (deficient) or in too large a supply (excess) in the soil, the plant cannot function to its maximum capacity. More often a deficiency rather than an excess of one or more elements occurs.

The crop usually show this by certain signs on its foliage, root, fruit or the whole plant. These are called signs of deficiency or hunger signs. If less than 10% of the plants show these signs, it is very unlikely that a deficiency exists.

Here are the hunger signs shown on various parts of the plant for each element. (Positive results are best determined from chemical tests.)

(10:25) **Hunger Signs On -**

NUTRIENT	Leaves	Root, stem or fruit	Whole plant
Nitrogen (N.)	1. Pale green to light yellow in colour 2. Drying up or firing of leaves starting with lower leaves	1. Reduction in size of fruits.	1. Slow, stunted. 2. Reduction in yields.
Phosphorous (P)	1. Purplish colour especially in the veins eg. cabbage	1. Purplish colour slender stems.	1. Slow growth 2. Plant tend to fall over when slender stems cannot support leaves. 3. Delayed maturity and reduced yields.
Potassium (K)	1. Mottling and curling starting with lower leaves. 2. Scorching or drying of margins starting with the lower ones	1. Roots poorly developed with plants tending to fall down. 2. Uneven ripening with some fruits spongy or hollow eg. in tomato.	1. Slow growth 2. Reduced yields.
Calcium (Ca)	1. Light green bands along leaf margins. 2. Tip of young leaves curl backward and	1. Weak stems 2. Short roots with excessive branching.	1. Slow growth. 2. Reduced yields.

Cont'd...

Deficient Nutrient	Leaves	Root, Stem or Fruit	Whole Plant.
Calcium (Ca) contd.	have hooked appearance. 3. Margins become wrinkled and sometimes young ones remain folded.	3. Blossom end rot of some fruits eg. watermellon.	
Magnesium (Mg)	1. Mottling (yellowing of leaf with veins staying green) 2. Leaves curl upward along the margins. 3. Light yellow or white streaks throughout entire length of leaf.	1. Slender weak stems. 2. Brittleness of stem and roots	1. Stunted growth
Sulphur (S)	1. Yellowing of leaves in the presence of adequate N	1. Short slender stems 2. Immature fruits light green in colour	1, Slow stunted growth in the presence of adequate N
Boron (B)	1. Margins become yellow or brown	1. Cracks on stems of some plants 2. Heart rot of tubers and fruits.	1. Reduced yields
Copper (Cu)	1. Leaves become yellow in some crops in presence of adequate N and Mg. 2. Tend to become elongated and flabby in presence of adequate water.	1. Some tubers become soft in presence of adequate water eg. turnip.	1. Slow growth. 2. Reduced production.

Iron(Fe)	1. Yellowing of younger leaves in the presence of adequate N	--	1. Reduced growth and production.
Mang anese(Mn)	1. Pale green or reddish colours between green veins.		1. Reduced growth. 2. Reduction in the number of fruits formed.
Molybdenum (Mo)	1. Leaves pale, distorted in shape and narrow in some crops	1. Poorly developed e.g. cauliflower.	1. Stunted growth 2. Reduced yield.
Zinc (Zn)	1. Buds white in some crops or white streak throughout entire leaf in others, eg. corn	1. Poorly developed fruits.	1. Flowering and formation of fruits delayed. 2. Reduced yields.

(10:26) <u>Photographs showing some common hunger signs and an excess of N on Corn.</u>

CORRECTING NUTRIENT HUNGER

To correct nutrients in short supply, the vegetable grower will have to apply the elements either to the soil as a fertilizer or dissolve the fertilizer material in water and spray it on the foliage of the crop. (foliar spray). When foliar sprays are applied, the plant will absorb the element (s) through its leaves and stem.

Here are some materials and the quantities generally recommended to correct deficiency.

(10:27)

Deficient element	Fertilizer material and approx. analysis	Quantity to apply in solid	Quantity in spray
Nitrogen (N) Phosphorous(P) Potassium (K)	Apply a fertilizer which is high in the deficient element	Apply solid material as part of recomm. rate.	Apply liquid or easily dissolved material as part of recomm. in irrigation water.
Calcium (Ca)	Calcium carbonate - Ca (lime) Calcium chloride - 36% Ca Calcium nitrate - 20% Ca	Apply in fertilizer (or liming material on acid soils) at recommended rates.	1/2 - 1 lb / 10 galls. 1/4-1/2 kg/40 litre.
Magnesium (Mg)	Calcium magnesium - 20 to 45% Mg carbonate (dolomite lime) Magnesium sulphate - 10% Mg (epsom salt)	10-15 lbs / sq. chn. or 5-7 kg/ 400 sq. m. 15-20 lbs or 7-10 kg/400 sq. m.	1-1 11/2 lbs/ 10 galls 1/2-3/4 kg/ 40L.

Sulphur (S)	Use ammonium sulphate,& super phosphate to supply NPK.	Mix the fertilizers in proportion for NPK analysis recomm.	
Boron (B)	Borax - 11% B	(mineral) 1-2 lbs (soils) 2 1/2-5 lbs (organic soils)	4-8 ozs
	Solubor - 21% B	1/2 - 1 1/2lbs (mineral) 1 1/2 - 2 1/2lbs (organic)	not over 4 ozs.
Copper (Cu)	Copper sulphate 25% Cu (blue stone)	2 1/2 - 5 lbs (mineral) 10-30 lbs (organic)	4-8 ozs.
	Copper oxide -80% Cu	1-1 1/2 lb (mineral 3-9 lbs (organic)	(not soluble)
Iron (Fe)	Ferrous sulphate - 20% Fe	1-2 lbs	3 - 6 ozs.
	Iron chelate - 10% Fe	2-4 lbs	
Manganese (Mn)	Mangnanese sulphate- 25% Mn	2-3 lbs(mineral) 15-30 lbs (organic)	3 - 6 ozs.
Molybdenum (Mo)	Amonium molybdate - 50% Mo	1/4 - 1/2 lb	
	Sodium " - 40%Mo	not over 1/4 lb.	not over 2 ozs.
Zinc (Zn)	Zinc sulphate - 23% Zn	1-4 lbs	3 - 6 ozs.
	Zinc chelate - 14% Zn	1 1/2 - 4 lbs.	not over 2 ozs.

Note - 1. Apply foliar spray at rate and with same equipment for spraying insecticide.

2. Use a filler material (eg. sand) in applying small quantities.

3. Application of larger quantities than recommended might be toxic (poisonous) to some crops.

Chapter 11. PREPARING LAND

Before the vegetable farmer can grow his crops, he has to prepare the land on which they are to be grown. The major practices in land preparation are:-

1. Clearing
2. Ploughing
3. Harrowing
4. Furrowing

Whether or not the vegetable grower needs to apply all four, will depend on the state of his land. For instance if it is covered with short grass and there are no other obstacles the land can be directly ploughed. In some other cases where the farm is already established and a crop recently harvested, then clearing and ploughing might not be necessary.

Each operation can be done both by manual labour using cutlass, fork, hoe etc or by tractor with different equipment attached. A farmer working over an acre of land should try to use machinery to do his land preparation, if the terrain and slope of the land allows this. If he does not have his own, he should hire . The work is not only done more quickly but also more economicaly

Importance of land preparation.

The main purpose of preparing land is to clear away plants and other obstacles that would impede the cultivation of the crop and to loose up the soil. Vegetables produce more when their roots are free to move through the soil in absorbing nutrients. In unprepared soil, the soil itself act as physical barrier which impedes water movement in the soil and the root from spreading. The root cannot increasingly absorb nutrients and this retards absorbtion of plant food which would in turn further retard the development of the plant. The result is that unprepared or poorly prepared land tend to reduce yields.

1. Land preparation makes it possible for soil to absorb more water and for the crop to absorb more nutrients.

2. It allows roots to develop more rapidly.

3. It helps crops to increase yields and improves quality.

4. Land preparation makes it easier to plant crops.

5. During clearing, ploughing and harrowing the roots of most weeds are destroyed. This helps weed control.

<u>Determining the size of the plot of land</u>.

<u>Conversion table</u> - This table can be used by the vegetable farmer in determining the area of a plot of land (i.e. Plot size), or to know the measurements required for a certain areas. This will be illustrated in a minute.

(11:1)

LENGTH OF PLOT -

Approx. Chain & Feet	1/2 chn. (33ft.)	1 (66')	1 1/ 2 (100')	2 (132')	2 1/2 (165')	3 (200')	3 1/2 (231')	4 (264')	4 1/2 (300)	5 chn. (330')	metres) ↓
1/4ch(16ft)	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	5 m
1/2(33')	1/4	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/2	2 1/2	10 m
3/4(50')	3/8	3/4	1 1/8	1 1/2	1 7/8	2 1/4	2 5/8	3	3 3/8	3 3/4	15 m
1 (66')	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	20 m
11/4(82')	5/8	11/4	1 7/8	2 1/2	3 1/8	3 3/4	4 3/8	5	5 5/8	6 1/4	25 m
1 1/2(100')	3/4	11/2	2 1/4	3	3 3/4	4 1/2	5 1/4	6	6 3/4	7 1/2	30 m
1 3/4(116')	7/8	13/4	2 5/8	3 1/2	4 3/8	5 1/4	6 1/8	7	7 7/8	8 3/4	35 m
2 (132')	1	2	3	4	5	6	7	8	9	10	40 m
(148')	1 1/8	2 1/4	3 3/8	4 1/2	5 5/8	6 3/4	7 7/8	9	10 1/8	11 1/4	45 m
2 1/2(165')	1 1/4	2 1/2	3 3/4	5	6 1/4	7 1/2	8 3/4	10	11 1/4	12 1/2	50 m
2 3/4(182')	1 3/8	2 3/4	4 1/8	5 1/2	6 7/8	8 1/4	9 5/8	11	12 3/8	13 3/4	55 m
3 (198")	1 1/2	3	4 1/2	6	7 1/2	9	101/2	12	13 1/2	15	62 m
(Metres →)	10m	20 m	30 m	40 m	50 m	60 m	70 m	80 m	90 m	102 m	metr- res

Areas given is Square Chain <u>or</u> approx. 400 sq. Metres.

(1) The top row (going across) gives measurement of the length of the plot in chains. Approx. feet are given in brackets. The bottom row gives the measurements in metres.

(2) The extreme left columns (going down) gives measurement of the width in chains. Approx. feet are also given in brackets. The extreme right column gives the measurement in metres.

(3) The area of the plot for the corresponding measurements is given in boxes in approx. square chains. (Multiply by 400 to convert to square metres)

(4) The area (A) is calculated from multiplying length (L) of the field by its width (W).

i.e. Area = (LxW)

How to use the table.

1. To find area of a plot:

(1) Measure the length and width of the plot.

(2) Look at the top row for the corresponding length and rest a finger above it.

(3) Look to the extreme left column for the corresponding width and put a straight edge along this row.

(4) Run a finger along the straight edge until it comes under the other finger marking the length.

(5) Check the figure in the box. It tells the area of the field.

Example 1.

A farmer measures a plot which is 2½ chains long and 2 chains wide. What is the area of this plot.

Answer - Area = 5 sq. chns.

(Check the table and see how this is found).

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* To convert chain to metre x 20.
To convert sq. chn. to square metre, multiply by 400. The areas in the box are for sq. chn. or are fractions of 400 sq. metre.

A. CLEARING

1. Use a tractor (bulldozer) to remove the big trees and as much of the smaller vegetation and stones as is economically sensible. Manpower can also be used to chop down and dig out the roots of bigger trees. This takes more time and is more expensive, but sometimes, is the only means available.

2. Burn the trees in heaps and the rest of the land if necessary. Regular burning of the land is not a good practice as it removes organic matter from the surface of the soil. But sometimes it is the cheapest and quickest means of clearing the land. The roots of trees that are left in the soil, can be removed after ploughing. The farmer should always clear remains of shrubs that will not be easily cut up into the soil at ploughing and harrowing. Some tall fibrous grasses are like this and creates serious problems in making furrows and plant beds. Burning is needed in this case.

Burning should be looked at also from its economic value i.e. how it will affect the business in the short and long run.

Example.

Here are our peasant friends Bongo using mechanical means of clearing and Kojo burning his land.

Bongo		Kojo	
Cost of cutting shrubs	$20	Cost of matches	$0.05¢
Cost of removing shrubs	$10	Cost of fertilizer compensate for nutrients	$3.00
Cost of weeding during the crop	$20	Cost of weeding during the crop	$15
TOTAL	$50	TOTAL	$20.05

50 kg or 100 lbs of /10-10-10 fertilizer supply more nutrients than a ton of fresh grass manure.
Burning also helps to control weeds.

B. PLOUGHING

Ploughing is the first step in the loosening up of the soil for cultivation. During this operation, the soil is cut into long slices and the top soil, rich in nutrients is turned under in the reach of the roots (root zone) of the crops.A tractor with a plough attached to it usually does this quite adequately.

Tractor ploughing land

(11:2) (a) A single mould-board plough (top) and a disc-plough (bottom)

Types of plough

Two types of plough are commonly used viz

(a) mould - board plough

(b) disc- plough

Mould - board - The mould-board plough resembles the old-time cow plough with a single blade attached to a beam. The beam is attached to the drawbar of the tractor. The depth at which it ploughs can be adjusted on the tractor and during work, the plough can be raised or lowered by the hydralic system of the tractor. In some cases, 2 blades are put on the beam and can be used one at a time in such a way that the tractor can plough in two direction on the same side of the field. We will understand this some more when we look at actual ploughing. This is the reversible plough.

Disc-plough - The disc-plough is made up of a number (2 - 4) of discs. attached to the beam. The angle of the discs can be adjusted to determine the width of a single cut. The depth at which it ploughs can also be adjusted and the plough can also be raised and lowered by the tractor. Large and small tractors use both types of ploughs.

Ploughing like most operations in vegetable production is one that requires skill for the best results. These skills are best developed with experience.

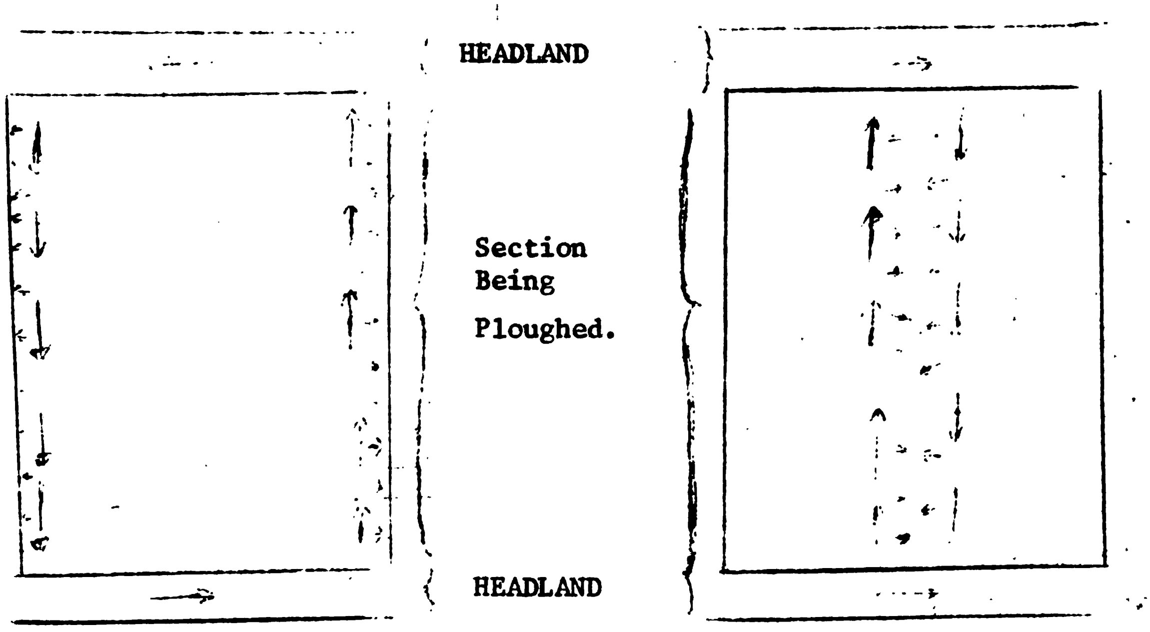
How to plough

There are 3 widely used methods of ploughing that can be used with both mould-board and disc-ploughs.

(a) Casting

(b) Gathering

(c) Round and round ploughing



(11:3) (a) Casting - ploughing starts on the side (b) Gathering-ploughing starts in the middle

(Tall arrows (↑) in the section indicate movement of tractor. The short arrows(→) show the direction in which ploughed soil is thrown)

At the start of the operation, a strip of land at both ends of the field across its width is marked off. This will be mainly for turning the machinery through ploughing and later land preparation. It will remain unploughed and should vary from 5 - 10 ft. depending on the size of the tractor. This is the head-land.

Casting - In casting, ploughing starts on the side of the section. The first slice of land (also called furrow) is cut from one end of the plot to the other end along its length. The second cut is made on the other side with the cut made in the opposite direction. The blade of the plough usually faces the right, the turn is made to the left so that ploughed area will be on both sides of the section. The plot will be completed when both portions meet in the middle. Fig. (a) illustrates casting. Note the direction in which the ploughed soil is thrown.

Gathering - In gathering, ploughing starts in the middle of the section. The first slice is cut in the middle of the plot from one end to the other. A sharp turn is made to the right to make the second cut on the other side of the first. So that the ploughed area is together and is widened after each turn. Ploughing will finish on the sides of the section. In both casting and gathering, the movement across the field is done on the head-land.

Round and round ploughing -

In both casting and gathering, at the end of each cut, the plough is lifted and no ploughing is done across the field. There is some variation to these two methods. One known as round and round ploughing is done as its name suggests. It resembles casting in that it starts on the sides and moves towards the middle. But the plough is not lifted when going across the field. The main objections is that some areas at the corners might not be properly ploughed. When the tractor is positioned to go across the field a head-land might be left but is not used during ploughing.

Vegetable growers should try the 3 methods in addition to others that they should develop for themselves in time. Each grower should see which method gives him greatest efficiency. It is best to plough land when it is moist.

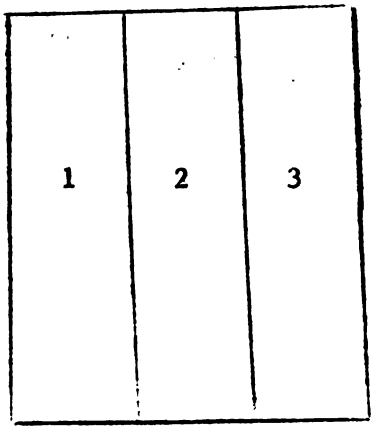
Despite the method used, remember this -

Turn the tractor in such a way that the ploughed soil is thrown on land that is already ploughed.

Ploughing in sections.

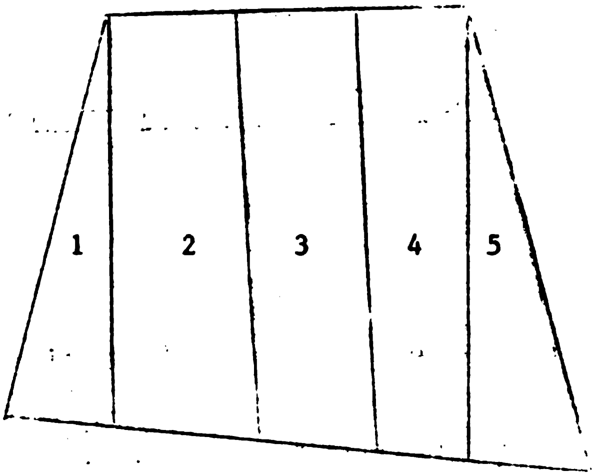
In casting and gathering, the field should be divided into section not more than 1 chain across for big tractors and about 1/2 chain across for small tractors. By dividing the field in section, the operator actually cuts down on the amount of distance that the tractor covers while not actually ploughing. This makes the operation more efficient and saves money for fuel. The length of the section is not important. If the section is small and a big tractor is used, the operator will have to reverse at the end of each cut and ploughing might have to be done on one side. It is best to use small equip ment in small sections.

(11:4) (a) For rectangular fields



Divide the field into retangular sections of not more than a chain across Fig. illustrate this with the numbers showing the order in which the sections can be ploughed.

(b) For fields of other shapes



Divide the field into sections to get as many rectangular sections as is practical. Fig. illustrates this with the numbers also to show the order of ploughing the section. The tringular areas can be ploughed by the round method.

In summing up ploughing -

1. Be careful with machinery. They do not respect human life (This goes for land preparation in general).

2. Turn the tractor in such a way that the ploughed soil is thrown on land that is already ploughed.

3. Plough the field in sections.

4. Plough the land when the soil is suited for efficient ploughing. For example, do not plough wet land, the equipment will skid. This damages machinery and could endanger the life of the operator.

After the grower finished ploughing his land, his field is now ready for harrowing.

C. HARROWING

After ploughing, the field is usually in large slices of soil or a generally lumpy condition. The surface soil has been turned under and sometimes only bits of vegetation give some evidence of what the soil surface was like. During harrowing, clods and slices of earth are broken up and the soil made more refined. A rotovator can be used to plough and harrow in one operation if the land is not too tough.

Implements -

When done separate from ploughing, the equipment that does this work is called a harrow. It is made up of 2 to 4 cross-bars to which are attached a number of discs. Like the blades of the plough, the disc can spin on the cross-bar.

The sets of blades on each bar can be adjusted and can be lifted with large tractors. The cross-bars are attached to the draw-bar of the tractor and during harrowing the blades are kept at a slight angle to cut the soil.

Later we will see that 2 sets of blades attached at a greater angle can be used to make banks for planting the crops.

(11:5) Top) Harrowing after ploughing
Bottom) Ploughing and harrowing in a single operation. The equipment used is called a rotary cultivator (rotovators).

How to harrow a field

Harrowing is a less technical operation than ploughing. The soil is most suited a few days after ploughing when some of the moisture in the newly exposed soil has dried out. It should then be dry to slightly moist before it is harrowed. This is to allow for the greatest efficiency in breaking up of the lumps.

The field might be taken up in sections but this is not necessary as the method used will be more or less like the round and round ploughing. The direction of turning is not as important as in ploughing. For some soils, especially when they are to be worked for the first time, harrowing should be done twice. However, the number of times harrowing is done depends on -

1. The type of crop to be planted. Generally the soil should be more refined for smaller seeds to be directly planted. This also holds for root crops. If the soil is in lumps that are not easily broken down, the tuber will be deformed.

2. The type of soil being prepared. How much a soil has to be worked to a certain tilth (how refined or how course) is directly related to the texture of that soil. For instance, a sandy soil generally needs less harrowing than a clay soil for a certain tilth.

For growing a short crop, harrowing the field twice might either eliminate or reduce the need for controlling weeds. Finally the vegetable grower will have to make his own judgement as to how much to harrow his land.The farmer in particular must remember that his operation is not for maximum production, but for maximum economic returns.

FURROWING

Furrowing is the final stage in preparing land for planting vegetables. This operation is mainly concerned with drainage. During furrowing, small trenches are cut in the field going in one direction.

The trenches are the furrows and the raised area between two furrows is called a bank or plant bed. In this book, plant beds will be most often used to avoid confusion with raised sides of a river or road-way. But one can see where the idea of calling the plant beds "banks" originated.

In some cases, the crop is not planted on the raised area, but in the trenches. This is mainly when crops are grown under conditions of limited moisture.

How to cut furrows.

1. Decide the distance apart at which the furrows will be cut. Then adjust the equipment to do this work.

   For small tractors use -
   - a mould-board plough adjusted for shallow cutting.
   - a pair of disc with their concave (curved-in) sides facing each other and adjusted at an angle for the required depth of the furrow.

   For the big tractor use -
   - a ridger i.e. an implement with one to three attachments resembling 2 blades of mould-board plough put together. The blades are attached to a cross-bar and can be adjusted to vary the distance between the furrows.
   - a harrow with two sets of blades and adjusted at an angle and distance for cutting the furrows.

2. Cut the first furrow at one side of the field. Then turn the tractor on the headland to make the other one beside the last one

while moving in the opposite direction. Continue in this way and prepare the furrow. on one side until the whole field is completed

(11:6) a. Top - cutting furrows with plough

b Bottom - cutting furrows with discs.

c. Top-cutting furrows with ridger

d. Bottom - cutting furrows with harrows.

Distance between furrows.

The distance at which furrows are cut depend on a number of factors. Some important ones are:-

(a) Soil type

(b) Amount of available water and the method of applying it.

(c) Slope of land

(d) Planting distance of crop.

Soil type - Because furrowing plays such an important part in drainage and drainage is so clearly related to soil type, then this will help to determine the distance between two furrows. Remember that the soil type is determined mainly by the texture i.e. the size of its particles. Now sandy soils usually have a more rapid natural drainage.

This means that -

1. For sandy soils, furrows are generally placed at a greater distance apart from each other. In some cases, where drainage is very rapid, furrows might not be necessary at all.

2. For clay soils, furrows are generally placed nearer to each other. In cases where drainage is very slow each bed should be not more than 3 ft. approx. 1 metre wide.

Amount of water - In thinking of available water, we have to think first of rainfall and secondly, irrigation water.
Let us get this plain -

1. If the crop is to be grown during a period of frequent rainfall, then generally, the distance between furrows should be less. i.e. furrows should be nearer to each other.

2. For growing in dryer periods, the furrows should be further apart if the crop is not going to be planted in the furrows. These two points hold despite the type of soil, but is more important for clay soils. This is because the slow internal drainage in most clays will become serious problem as more water is added to the soil.

3. If surface irrigation is used, furrows should generally be nearer to each other. As flood irrigation is not recommended for vegetable (transmit diseases, wash-off chemicals for insect and disease control), the greater the distant, the less efficient furrow irrigation is.

4. If over-head irrigation is to be used, the distance between furrows is not as important. The furrows will not act as channels for carrying water and if the soil has a good internal drainage, then they are not needed.

Slope of land - As the slope of the land increases the distance between furrows should be reduced. This is mainly to control erosion. On slightly sloping land of good drainage, furrows should not be too far apart (i.e.not more than 6 feet or 2 m. This is very important particularly, when the crop is young. Then, a heavy shower of rain will cause sheet erosion. If furrows are absent or too far apart, the seedlings will be covered in soil and their growth retarded.

Planting distance -

1. If a single row of a crop is to be planted on each bed, the furrows should be cut to allow the required distance between the rows. This also holds for situations when the crop is to be planted in the furrow.

2. If more than one row of crop is to be planted on a bank, the furrows should be so cut to allow the crops to be planted at the required planting distance.

Land prep. (contd.)

On some soils it is very difficult to apply the methods we have been discussing so far. One such condition is when the land is stony and machines cannot work on it. The second one is of such that machine can work, but using machine in the ways discussed would have adverse effects. Light clay loam soils (eg bauxite soil) is such an example.

1. These soils have very rapid internal drainage. When ploughed and harrowed, the soil is further loosened and holds very little moisture.

2. These soils have small particles, and when worked easily becomes powdery. Although they will not become water-logged when wet, they will tend to form clods and when dry will be easily blown away.

Here are some suggestions for working such soils.

Use manual labour to dig the holes for planting the crop. This is strenuous for workers and expensive to the farmer. The alternative is to use machinery, but the tractor should only be used to cut furrows and the crop planted in them. Try to get mulch to reduce water loss from the soil. Planting should be adjusted to the rainfall pattern of the area especially where irrigation water is limited.

B. FARM MACHINERY FOR LAND PREPARATION

Tractors and the impliments attached to them for ploughing (before planting and inter-row work) harrowing and furrowing, are of most importance to the vegetable farmer. Whether or not a farmer buys a tractor and the size of such a tractor depends on the amount of money he has and the size of his farm, each grower working on land of over 2 1/2 ac. or 1 ha. should try to get a small tractor and the basic attachments for ploughing and harrowing. In most cases, these can be adjusted to do furrowing and some inter-row ploughing as long as the terrain and slope of the land allows it.

Most small tractors are walking-tractors i.e. the operator has to walk while working it. They are usually tiring and because of this, limits the amount of work that can be done in a day. This is even more so if the work is on heavy clay or clay loam soils. (If these tractors were designed so that the operation could sit while working, this would make them more helpful to farmers.)

It is best that if the grower has over 2 1/2 ac. or 1 ha. of land to prepare at any one time, he hires a big tractor to do this where he does not have his own. In some cases, he can use his small equipment for making his banks. But they are useful for inter-row work and for ploughing small plots of land needed in a hurry. Besides, some small tractors can also be used as irrigation pumps.

But a farmer having up to 1 hectare of land, will find that if he organnizes his planting programme well in which case he prepares only sections of his field at a time. A small tractor can do a great deal if not all his land preparation.

Vegetable growers on peat-bog soils must use small equipment as large tractors are too heavy and will tend to stick while working in these conditions.

Buying machinery and other attachments.

1. Do not buy machinery from advertisements of the firm selling the equipment. It is best to talk to at least two farmers who have worked such equipment.

   If it is recently introduced into the country, then the individual vegetable grower or his co-operative should get a thorough demonstration of the equipment working under the conditions in the community.

2. i.e. Make sure that the equipment is suited for the area in which it is to work.

3. Buy through the farmers co-operative. For small vegetable growers, it is most times very difficult to buy small machinery and almost impossible and useless for each farmer to buy a large equipment. In this case, the individual farmer could have his own small tractor and a farmers co-operative organized in the community, buy one large tractor and its attachments to serve the need of all the farmers. This holds for land preparation and for other types of equipment

Remember this - 5 farmers with $20 each might be able to own what each farmer will need but no one can afford.

(11:7) Photographs of farm machinery for land preparation.

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Chapter 12. BUYING SEEDS AND PLANTING.

A. Buying Seeds

The vegetable farmer should always try to buy good seeds. i.e.

(a) Seeds with good germination (high percentage germination - % G)

(b) Mature, disease - free seeds that can support vigorous healthy growth after germination.

How to buy seeds.

1. Buy seeds from suppliers that sell fast. The chances of getting fresh seeds is greater although the farmer can never be certain that. he is buying fresh seeds.

2. Buy seeds for only one planting. This is important as fresher seeds are likely to have a higher % G and vigour than older seeds. When he keeps that supply for later plantings, he might find that he has a whole batch of useless seeds in his hand.

3. Buy seeds in sealed cans where large quantities are needed.

Producing own seeds -

For growing vegetables on a large scale, it is not recommended that growers try to produce their own seeds. Most high yielding varieties are the result of research done by specialist in plant breeding. In most cases, they breed a number of high-yielding varieties with other varieties that have some undersirable (bad) traits. A farmer who tries to produce his own seeds may find that after a few crops, his plant will show up these bad features. This will usually reduce the overall performance of the crop i.e. yield or other features like resistance to diseases. So that it is best for the grower in large-scale production to buy seeds from recommended producers. However, the back-yard gardener can produce his own seeds.

How?

1. Collect some well matured fruits. The amount collected will depend on how much seeds is needed.

2. Cut the fruits and squeeze the seeds in some water. For treating the seeds against disease and insects at planting (i.e. pretreatment,) add a fungicide and a compatible insecticide (i.e. both can work together) to the water. Captar and dieldrin can both be safely used at about 2 ozs each in 1-2 quarts of water.

3. Wash the seeds in the water for about one hour. Then put them to dry for a few days in the open.

Pre-treating of seeds with powdered insecticides and fungicide, can be done by applying the powder to the dry seeds or dipping the seeds before they are dry in a slurry made from the chemicals and a little water.

Testing seeds

The main reason for testing seeds is to determine the amount of seeds that is likely to germinate when planted. The amount that will germinate can be expressed as a fraction or as a percentage (% G). It is better to use percentages as for example, if 25 seeds are planted and 18 germinate it might not be too easy to find what fraction this is. But it is easier to express this as a percentage. The test would be made from the batch of seeds to be planted.

Why test seeds?

By knowing the % G of a batch of seeds, the farmer will know if he needs to -

1. Discard the seeds he now has and buy a fresh supply. It is better to have to buy another pack now than later after he has spent money to plant these bad seeds.

2. Adjust his planting plans to suit the % G of his seeds. If for example % G = 50, and the farmer planned to plant 2 seeds per hole, now he should plant 4 seeds. (He might need to do some thinning later). If he is planting in furrows and require plants 12 ins apart, he would now have to plant seeds 6 ins (15cm) along the row. He will also have some idea before planting of how much seeds he need to buy to plant his field in one operation. There will be no need for supplementary (or supply) planting of his field if he checks % G and use this before planting.

Example

Let us look at 2 farmers Bongo and Kojo who both bought seeds with approx. 50 % G. Bongo did not test his seeds while Kojo tested his.

Bongo (1st planting)	Kojo(1st planting)
Cost of seeds - $ 2 " of land prep. - $ 10 " of planting - $ 20	Cost of seeds - $ 2 + $2 " of land prep. - $10 " of planting - $20
TOTAL - $ 32	TOTAL - $34
(Supply planting) Cost of seeds - $2 " of planting - $10 TOTAL $12	No supply planting Additional $2 for seeds bought after testing % G.
Grand Total = $32 + $12	(Grand)Total - $34.

How to test seeds.

Learn this formula -

$$\% \text{ G} = \frac{\text{no. of seeds germinated} \times 100}{\text{no. of seeds planted}}$$

Steps - 1. Take 25 seeds from the pack to be planted. Try to get a random sample.

2. Cut a container (half of a drum-pan) and fill it with soil. Then either treat the soil with an insecticide or saturate it with boiling water.

3. After the soil is cool, plant the seeds in it.

4. Water the seeds regularly (once per day or per two days depending on the type of soil in the pan). Make sure that it is not kept soaking wet or, too dry.

5. After the approximate number of days or a few days later than the crop is supposed to take to emergence, count the number of young plants that emerged.

6. Calculate the % G of the seeds. For example if 20 seeds germinated,

   then $\% G = \frac{\text{no. of seeds germinated}}{\text{no. of seeds planted}} \times 100$

   $\frac{20}{25} \times 100 = 80\%$

Another method of testing seeds.

Take the 25 seeds from the pack to be planted and put them between a few pages of newspaper. Put the paper in a cool place and wet it enough to keep it moist. About 2 days after the time the seeds of that crop is supposed to take to germination, count the number of germinated seeds. % G can be calculated as in the first method.

Using results.

1. When seeds are below 30%, do not plant them. It will be better to buy a new supply as planting these are going to create problems to get equal distribution of plants.

   Between 30 to 50 % G, seeds can still be used for small sc farming, putting 3 seeds at each place where a plant is required to grow.

2. For 50 - 65%, plant twice the amount that was planned for the given area.

3. For 65 - 80%G plant one and a half (1 1/2) the amount that was planned for the given area.

4. For 80 - 95%G, plant about one and a quarter (1 1/4) the amount that was planned for that area.

5. When seeds are over 95%G, plant the amount that was originally planned for that area.

Later, we will see a more accurate means of calculating the quantity required for the % G determined by the test.

B. PLANTING

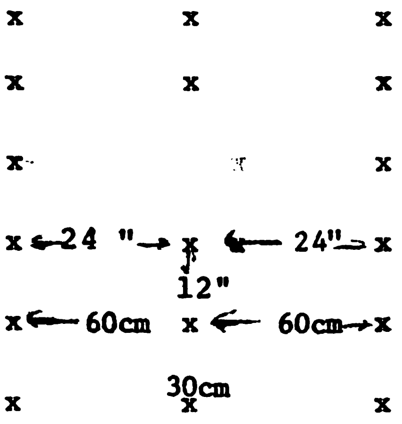
So far we have been looking on a number of practices that are preparation work for planting the crop. This practice include making a number of plans before the seeds are actually put in the soil. Three such jobs are:-

- determining correct planting distance
- determining quantity of seeds required for planting
- determining correct planting time.

DETERMINING CORRECT PLANTING DISTANCE

What is planting distance?

The planting distance of a crop as the names suggest refers to how far apart plants are from each other in the field. This distance is expressed with 2 measurements, viz, the distance between rows of plants and distance between plants in a row. The distance between the rows is usually the larger figure.



(12:1) pl. dist. of 24" x 12" (60 x 30 cm.)
x = plant

Example

A crop like corn might have a planting distance (pl. dist.) of 24" x 12" i.e. 24 ins between rows and 12 ins between plants in row (or 60 x 30 cm). We will see later when we come to look at populations, that a crop does not always have the same planting distance. Its planting distance can be different in different areas or on different farms in the same area. However, as standard is a range of planting distances

Range of planting distances

The range of planting distance of a crop is expressed as - the range of distance between rows x range of distance along rows.

Example.

A recommended standard range for corn is 24 - 48 x 12-24 ins.[*] (This read 24 to 48 by 12 to 24). It means that the crop can be planted at distances from 24 ins to 48 ins between rows (i.e. 24", 25" etc. up to 38") and from 12 ins to 24 ins along the row. (i.e. 12, 13, 14 etc. up to 24").

So that a farmer following this recommendation will plant corn at 12 x 24 ins, another at 15 x 30 ins, another at 20 x 48 ins and so on. But the planting distance should be kept within the recommended range.

These ranges are given from considering among other factors -

1. Growth habit of a crop - i.e. does it produce a lot of foliage, does it trial for long distances, will it grow tall and slender how will these features limit yields of the crop if it planted above or below a certain planting distance.

2. Crop NPK - i.e. what is the nutrient requirement of the crop and how will it produce if planted above or below a certain dist. on a given soil.

   But the range is usually determined by experimenting with the crop to see what planting distances give best production and economic returns under different conditions. Sometimes factors like rainfall and more problems with pests and disease at higher populations have to be considered in deciding on populations for certain crops.

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[*] Multiply by 2.5 to convert to cm.

Plant populations (or plant density)

The plant population is the number of plants of a crop that is grown in a given area of land. This is usually expressed as number of plants per unit area (per square chair, per acre, or per hectare).

Example

If 30,000 corn plants are being grown on 2 acres of land, the population can be expressed as 15,000 plants per acre (OR 1,500 plants / sq. chn. or 1,500 plants / 400 sq. m)

$$\text{Pop}^{n} = \frac{(\text{no. of plants})}{(\text{ unit of area})} \text{ plants / unit area}$$

$$\text{Pop}^{n} = \frac{30{,}000}{2} = 15000 \text{ plants / acre.}$$

$$\text{OR} = \frac{30{,}000}{20} = 1500 \text{ plants / sq. chn}$$

Importance of correct populations.

The vegetable grower should try to use the correct population for each of his crops. - Why?

1. Correct population - gives maximum total yields. This might not be the population at which the average yield per plant is nearest to its maximum.
   - produces good quality fruits.
   - allows easy movement to apply other practices eg. weed and pest control, reaping

2. Under-population - gives less than maximum total yields although the average yield per plant might be above that at the correct population.

- produces quality of fruits that might be above that of correct population. However, fruits might be too big and not suited for market requirements.
- allows easy movement in the field with wasted land space.

3. Over-population
   - gives less than maximum total production with average weights of fruits below that given from both under-population and the correct population.
   - produces excessive foliage growth.
   - this lower yield and fruit quality can be due partly to insects and diseases. The higher the population the damper the area around the foliage and this encourages more pests. The problem of moving in the field, further makes control more difficult.

(12:2) Poor spacing in tomato causes excessive foliage growth and poor fruiting.

The correct population of a crop on a given soil is determined largely by the nutrient requirement of the crop (i.e. Crop NPK) and the total nutrient level of that soil (i.e. Soil NPK).

How are populations and planting distance of a crop related?

Before the vegetable grower can determine his planting distance, he should know the plant population that he requires for growing his crop. To determine correct planting distance for a crop -

1. Find the recommended range of planting distances for the crop.
2. Decide the population for growing that crop on the soil conditions of the farm. (Remember that this goes with the fertilizer rate to be used).

3. Calculate suitable planting distances within the recommended range that will give the correct population allowing for the use of equipments on the farm.

Generally, it is best to keep planting distances as square as possible within the recommended range and population. This allows a better distribution of the crops and more efficient use of plant nutrients, water, light etc. by the crop.

Example:

> Pl. dist. of 24" x 18" for corn is likely to give better yields than 36" x 12" although both give the same population and is within the recommended range of pl. distance for the crop. But in fact, the equipment on the farm and other factors like ease of reaping might make 36" x 12". The better distance to plant corn on that farm.

Sometimes, it is time-wasting and just not convenient for a tractor to plough one section of a field making rows 18 ins. apart and another 15" and another 12". As long as one stay within the recommended range, the entire field would be prepared at, say, 18" and the crops planted at different distances along the row according to the required population.

Recommended range of planting distance and population levels.

(12:3)

CROPS	Range of Planting dist.* (inches).	Pop^n levels (pl. per sq. chn or per 400 sq. m.)		
		Low (Pop^n_L)	Medium (Pop^n_M)	High (pop^n_H)
Beans(bush)	15-30" x 4- 8"	2500- 5200	5200- 7900	7900 -10500
Beans(pole)	15-30 x 8-12	2000- 3000	3000- 4000	4000 - 5000
Beet	15-24 x 2- 4	6000-11000	11000-15000	16000 -21000
Brocolli	18-36 x12-24	800- 1500	1500- 2200	2200 - 2900
Brussel sprout	24-36 x12-18	1000- 1400	1400- 1800	1800 - 2200
Cabbage	18-36 x12-18	1000- 1600	1600- 2200	2200 - 2900
Calaloo	12-24 x 3- 6	8800-11700	11700-14600	14600 -17600
Carrot	15-24 x 2- 4	6100-11000	11000-16000	16000 -21000
Cauliflower	18-36 x12-18	1000- 1600	1600- 2200	2200 - 2900
Celery	15-30 x 4- 9	4600- 6500	6500- 8500	8500 -10500
Chard	18-30 x 6-12	1800- 3100	3100- 4400	4400 - 5800
Corn	24-48 x12-24	600- 1100	1100- 1600	1600 - 2200
Collard	24-36 x12-18	1000- 1400	1400- 1800	1800 - 2200
Cucumber	24-48 x12-18	800- 1200	1200- 1700	1700 - 2200
Endive	18-24 x 8-12	2200- 2900	2900- 3600	3600 - 4400
Escallion	12-24 x 2-4	13000-17300	17300-21600	21600 -26000
Garden-egg	24-36 x15-30	600- 1000	1000- 1400	1400 - 1800
Kale	15-24 x12-18	2200- 2600	2600- 3000	3000 - 3600
Kohl-rabi	12-24 x 3- 6	4400- 8800	8800-13200	13200 -17600
Leek	12-24 x 3- 6	4400- 8800	8800-13200	13200 -17600
Lettuce	12-24 x 6-12	2200- 4400	4400- 6600	6600 - 8800
Muskmellon	36-48 x12-24	600- 900	900- 1200	1200 - 1500
Mustard	12-24 x 6-12	2200- 4400	4400- 6600	6600 - 8800

(12:3 cont'd.)

CROPS	Range of pl. dist*.	Low Pop^n	Med. Pop^n	High Pop^n
Okra	24-48"X15-24"	600 - 1000	1000- 1400	1400- 1800
Onion	12-24 x 2- 4	13200 -17500	17500-21800	21800-26000
Parsley	12-24 x 3- 6	4400 - 8800	8800-13200	13200-17600
Parsnip	12-24 x 2- 4	13200 -17500	17500-21800	21800-26000
Pea	18-24 x 3- 9	2900 - 5800	5800- 8700	8700-11600
Peanut	12-24 x 2- 6	4400 -11600	11600-18800	18800-26000
Pepper	18-30 x 9-18	1200 - 2100	2100- 3000	3000- 3900
Potato	24-48 x12-24	600 - 1100	1100- 1600	1600- 2200
Pumpkin	48-72 x18-36	300 - 450	450- 600	600- 800
Radish	12-24 x 1- 3	8800 -23200	23200-37600	37600-52000
Spinach	12-24 x 3- 6	4400 - 8800	8800-13200	13200-17600
Squash	36-48 x12-24	600 - 900	900- 1200	1200- 1500
Tomato	24-48 x12-24	600 - 1100	1100- 1600	1600- 2200
Turnip	12-24 x 2- 4	13200 -17500	17500-21800	21800-26000
Watermellon	36-60 x12-24	500 - 800	800- 1100	1000- 1500

Note 1. The maximum population is calculated by multiplying the minimum distance between the rows by the minimum distance along the row for each crop. The minimum population is calculated in the opposite way ie. min. pop^n = max. pl. dist. bet. rows x max. pl. dist. along rows.

2. Generally, the 3 levels are roughly equal and are determined by subtracting minimum population from max., dividing and the difference by 3. The result is then added to the minimum pop^n., until the maximum is again reached.

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* Multiply distance in inches by 2.5 to convert to cm.

Choosing a population from the given population levels.

When we discussed fertilizers, we saw that the rates for growing a crop will depend on the nutrient requirement of the crop (i.e. low, medium, high feeder), the amount of nutrients in the soil, and the plant population that will be used. All 3 factors work together. Let us look back the table 10:13b on p.

We see that a low, medium or high population can be grown on each soil type using different amounts of fertilizer. But the grower himself will have to decide what population and fertilizer rate he should use. This will depend largely on what combination seems most profitable to use and is best determined by a population trial.

The populations are given as a range so that the grower can make a wider choice to suit his particular condition . In growing the crop for the first planting, use a medium population. (population within the range of the medium population level) If the grower feels that by increasing his population (and fertilizer rate) he could increase his profit, then an increased population should be used. The same would hold for decreasing the population.

s more
As the soil become/fertile, the grower can continue to increase his population and if possible cross over from one range into the other. He should also be careful about over-populating his field. This reduces quality.

(14:4)

TABLE FOR CALCULATING PLANTING DISTANCES

——— DISTANCE BETWEEN ROWS ———

Distance along row ins).

Ins	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	72"	cm.
1'ins)	52000	42000	35000	30000	26500	21000	10000	5000	13000	12000	11000	9000	3 cm
2'ins)	26000	21000	17400	15000	13200	10500	9000	7500	6600	6000	5400	4500	5 cm
3 ins)	17600	14000	11600	10000	8800	7000	6000	5000	4400	4000	3900	3000	8 cm
4'ins)	13000	10500	8700	7500	6100	5300	4500	3800	3300	3000	2800	2300	10 cm
5"ins)	10400	8500	7000	6000	5300	4200	3600	3000	2600	2400	2200	1800	13 cm
6"ins)	8800	7000	5800	5000	4400	3500	3000	2500	2200	2000	1800	1500	15 cm
9"ins)	5800	4600	3900	3400	2900	2300	2000	1700	1500	1300	1200	1000	23 cm
12"ins)	4400	3600	2900	2500	2200	1800	1500	1250	1100	1000	900	700	30 cm
15"ins)	3500	2800	2300	2000	1800	1450	1200	1000	900	800	700	600	37 cm
18"ins)	2900	2400	2000	1700	1500	1200	1000	850	750	650	600	500	45 cm
21"ins)	2500	2000	1700	1400	1300	1000	850	700	600	550	500	450	53 cm
24"ins)	2200	1800	1500	1200	1100	900	750	600	550	500	450	400	60 cm
27"ins)	2000	1600	1300	1100	1000	800	700	550	500	450	450	350	67 cm
30"ins)	1800	1400	1200	1000	900	700	600	500	450	400	350	300	75 cm
36ins)	1500	1200	1000	850	750	600	500	430	380	330	200	250	90 cm
cm	30.cm	37	45	53	60 cm	75	90	105	120cm	135	150	180cm.	

Distance along row (cm)

Distance between rows (cm)

Population expressed in plants per sq. chn. or per 400 sq. metre.

To calculate population / sq. acre, multiply figures by 10.

To calculate population per hectare, multiply figures by 25.

How to use the table:

1. Determine the required population for the crop on the soil it is to be grown. (check table 12 & 13)

2. Determine a distance between rows within the recommended range that is suited to the equipment on the farm (for cutting furrows, inter-row ploughing) and will generally allow movement for efficient application of other practices.

3. Find the distance or the nearest one to it on the top row of the table. Put a finger on the measurement. (The top row is in inches and the bottom row gives the same measurement in cms.)

4. Look at the figures in the column under the one you marked until you see the nearest figure to the required population.

5. Put a ruler or straight edge under this figure. Look to the extreme left of the table, and read the figure in the box immediately above the ruler. This is the required distance along the row for planting the crop. (The extreme left column gives the distance in inches and the extreme right in cms.)

Note- Remember that in planting the crop it will almost be impossible to get the exact population. If you want a population of 21,000 plants / acre and the nearest figure on the table is 20,000, it is quite alright to use the readings for the 21,000 plants. Dont worry you would be surprised to know that when you are finished planting, you might well be nearer to 21,000 than 20,000.

Example 1.

Corn is to be grown at a population of 18,000 plants/ sq. chn. with a distance of 24 ins between rows. Then find the column on the table for the distance of 24 ins (6th from the left.). Look at the figures going down the column, we see 1800 in the 9th box down. The distance along the row would be 15 ins. The required planting distance would be 24" x 15".

The grower should use his head to make the best of the table. He will need to do some estimation. For instance, he wants a population for 2,500 plants /sq. chn. and he decides to plant at 24 ins. between rows. This population is not on the table, but we see that 24 x 9" gives 2,900 and 24 x 12 gives 2,200 plants. The required distance would be between 9 and 12 ins. A fair estimate would be to use a planting distance of 24 x 10".

How to make your own calculations of planting distances.

For doing this, it is easier to make the calculations for 1 square chain (i.e. 1 chain x 1 chain). Three steps are involved.

Step 1. - Calculating number of rows in the given area.

$$\text{No. of rows} = \frac{\text{width of given area}}{\text{dist. between rows}}$$

Example 1.

Corn is to be grown at a population of 18,000 plants/ acre with 24 ins between rows.

$$\text{No. of rows in a sq. chn.} = \frac{66\text{ ft.}}{2\text{ ft.}} = 33\text{ rows}$$

Step 2. Calculating the number of plants per row.

Population per unit area = No. of rows per unit area x no. of plants / row

$$\frac{\text{Pop}^{n}\text{ per unit area}}{\text{No. of rows}} = \text{No. of plants / rows}$$

Example 2

Corn is to be grown at a population of 18.000 plants /chn. (i.e. 1800 plants/sq. chn) with 24 ins between rows.

$$\text{No. of plants per row} = \frac{1800}{33} = 54\text{ plants/chn.}$$

Step 3. Calculating distance along row

$$\text{Dist. along row in inches} = \frac{\text{Length of row in feet} \times 12}{\text{no. of plants per row}}$$

Example 3

Corn is to be grown at a population of 18000 plants / acre (i.e. 1800 plants / sq. chn.) with 24 ins between rows. (Field is 1 chain long).

$$\text{Dist along row in inches} = \frac{66}{54} \times \frac{12}{1} = 14.6 \text{ ins}$$

Approx. dist. along rows = 15 ins.

Required planting distance for the crop is 24 x 15 ins. Check the table and compare the results.

A note on planting measurements.

All general recommendations and particularly measurements in this book are given merely as a guide tothe vegetable grower. Time should not be wasted in trying to use exact measurements. For example, a planting depth of 1/2 - 1 inch might be given for a crop. While the grower should try to keep within this range he will not have a ruler in the field, so that some of his seeds will be 1/2 in. some 1 in., some 1 1/2 in. and even a few will be planted at 2 ins. deep. No harm.

It is the same thing with planting distances between rows and along the row. Note that machines will give greater accuracy.

In the same way, a grower needing 50 lbs fertilizer, while it is best for him to weigh it. He should not hesitate to estimate a half of a 100 lb bag and use this. This would not apply to a student doing a trial either with planting distances or with fertilizer rates. He needs to be dead accurate.

The second important point is the need to adjust planting distance to get the correct population according to the % germination test.

Use this formula.

$$\text{Seeds to be planted} = \frac{\text{Reqd Pop}^n}{\% \text{ G.}}$$

Example.

Farmer wants to plant a crop of beans at a population of 10,000 plants per. sq. chain. His % Germination tests show that his seeds are 80% viable.
How many seeds would he have to plant?
What planting distance should he use?

$$\text{Seeds to be planted} = 10{,}000 \times \frac{100}{80} = 12{,}000$$

Planting distance would be in the range of 15 - 30" x 4-9".
A correct planting distance would be 18" x 3 " (or 45 x 8 cm).

Determining quantity of seeds required for planting

Table - Here is a table that should be helpful determining how much seed is needed to plant various crops. This will be in the range given below, but the actual quantity has to be calculated.

(12:5)

Crop	Recomm. range of pop^n (plants/sq chn) (or pl./400sq. metre)	Approx. no. of seeds/oz or in 30 gms	Minimum %G to expect from good seeds	Approx. quan.** of good seeds Medium to High pop^n
Beans (bush)	2500 - 10500	100	75	4 - 7 lbs.
" (pole)	2000 - 5000	50	80	6 -12 lbs
Beet	6000 - 21000	1500	65	3/4 - 1 lb
Brocolli	800 - 2900	9000	75	
Brussel sprout	1000 - 2200	8500	70	1/2 - 1 oz
Cabbage	1000 - 2900	8500	75	
Calaloo	8800 - 17600	25000 (est*)	80 (est.)	1/2 - 1 oz
Carrot	6100 - 21000	20000	55	1 1/2 - 2ozs
Cauliflower	1000 - 2900	10000.	75	1/2 - 1 oz.
Celery	4600 - 10500	70000	55	1/4 -1/2 oz.
Chard	1800 - 5800	1500	65	1/4 -1/2 lb.
Corn	600 - 2200	150	75	3/4 -11/4 lb
Collard	1000 - 2000	8000	80	1/4 -1/2 oz
Cucumber	800 - 2200	1000	80	11/2 -3 ozs.
Endive	2200 - 4400	26000	70	1/4 - 1/2 oz
Escallion	13000 - 26000	10000	70 (est)	1/2 - 3 ozs.
Garden-egg	600 - 1800	6000	60	1/2 - 1 oz.
Kale	2200 - 3600	10000	75	1/4 - 1/2 oz
Kohl-rabi	4400 - 17600	8000	75	11/2- 3 ozs
Leek	4400 - 17600	11000	60	11/2- 3 ozs
Lettuce	2200 - 8800	25000	80	1/4 -1/2oz
Muskmellon	600 - 1500	1200	75	11/2-3 ozs
Mustard	2200 - 8800	15000	75	1/2 - 1 oz.

* est. = estimate

Crop (contd)	Recomm. range of Pop^n (plant/sq.chn	Approx. no. of seeds/	Minimum %G to expect from good seeds	Approx quantity of good seed needed for /sq chn **
Okra	600 - 1800	500	50	1/4 - 1/2 lb.
Onion	13200 - 26000	10000	70	11/2 - 3 ozs
Parsley	4400 - 17600	18000	60	1 - 2 ozs.
Parsnip	13200 - 26000	12000	60	11/2 - 3ozs
Pea	2900 - 11600	100	80	8 - 10
Pepper	1200 - 3900	4500	55	1 - 2 ozs.
Pumpkin	300 - 800	100	75	1/2- 1 lb.
Radish	8800 - 52000	2000	75	3/4 -11/2 lbs.
Spinach	4400 - 17600	3000	60	6 -12 ozs
Squash	600 - 1500	300	70	4 - 6 ozs.
Tomato	600 - 2200	11000	75	1/4 -1/2 ozs
Turnip	13200 - 26000	12000	80	1 - 2 ozs
Watermellon	500 - 1500	250	70	5 - 8 ozs

* Note - The Approx quantity of seeds will vary with different varieties and samples taken. These are more or less average figures.

To convert lbs to kg, divide figures by 2.

To convert ozs to gms, multiply figures in ozs by 30.

Calculating the quantity of seeds required for planting.

This formula should be helpful -

$$\text{Quantity} = \frac{\text{Pop}^n \text{ per area}}{\text{no. of seeds /wt.}} \times \frac{1}{\% \text{ G}}$$

Example 1.

What quantity of cabbage seeds (approx. 8500 seeds / oz) with 75% G would be needed to plant a crop with a population of 30,000 plants/ acre

$$\text{Quantity} = \frac{(\text{Pop}^n \text{ per acre}}{(\text{no. of seeds /ounce}} \times \frac{1)}{\%\text{G})} \text{ ozs/ acre}$$

$$= \frac{30,000}{8,500} \times \frac{100}{75} = 5.6 \text{ ozs.}$$

Quantity needed would be about 6 ozs. The actual amount needed should be set to the nearest 1/2 oz (1 oz) above that calculated. (See buying seeds).

Example 2.

What quantity of corn seed (150 seeds / oz.) with 75% G would be needed to plant a crop with a pop^n of 18000 plants / acre.

$$\text{Quantity of seeds} = \frac{(\text{ Pop}^n \text{ per acre}}{(\text{no. of seeds / oz}} \times \frac{1\ )}{\% \text{ G}} \times \frac{1}{16} \text{ lbs/ acre}$$

$$= \frac{18000}{150} \times \frac{100}{75} \times \frac{1}{16} = 10 \text{ lbs}$$

Quantity needed would be about 10 lbs. The actual amount needed should be set to the nearest 1/4 lb above that calculated (See buying seeds.)

Estimating the quantity of seeds needed.

Using Table 12:5, we can estimate the amount of seeds need for a population by finding what proportion of the highest recommended population, the required population is.

$$\frac{\text{Reqd. Pop}^{n}}{\text{Highest Pop}^{n}} \quad \times \quad \begin{array}{l}\text{Highest Quantity}\\ \text{of seeds Recomm.}\end{array}$$

Example 3.

A farmer wants to plant corn at a population of 18000 pl. on an acre of land. How much seeds he would need?

For planting 2200 pl. /sq. chn, he would need 1 1/4 lb.
(See Table 12:5) or 22000 pl. / acre, he would need about 12 1/2 lbs.
For planting 18000 pl, he would need $\dfrac{\overset{9}{\cancel{18000}}}{\underset{11}{\cancel{22,000}}} \times \dfrac{25}{2}$

$$= \frac{225}{22} \quad \text{Approx.} \quad 10 \text{ lbs.}$$

For buying seeds. -

1. In buying seeds before %G is tested, the grower should buy about 1 1/4 times the amount calculated. This will compensate for the need of thinning if direct seeding is done or will provide enough good seedlings for transplanting.

   Remember that additional amount might have to be bought depending on the %G of these seeds. This will definately be needed where the %G is below the maximum given in the table.

In this as in most other practices, the above are given as guides. The vegetable grower through his own experience and learning from other sources (particularly other farmers) will in time be able to know more definitely what he needs.

DETERMINING PLANTING TIME TO FIT RAINFALL.

The vegetable grower should be familiar with the seasonal conditions in his area. We have already seen how temperature and rainfall are important in selecting the crop that is to be planted in an area.

But even after selecting the crop that is suited to the area, this has to be planted at a difinite time to fit into the rainfall pattern and further reduce the farmer's problems.

Here are a few important points.

1. Try to avoid planting at or immediately before periods of heavy rain (or too light rainfall where the grower has to depend heavily on rain to supply water.)

   Heavy rains will cover seeds or young plants at a depth that could seriously retard their growth. It can also cause erosion of the soil and the washing out of the plants.

   In addition the problem of diseases like damping off and early blight disease on seedlings become more serious particularly on heavy soils.

2. Try to plant crops to avoid maturity in periods of heavy rain (or too light rain if adequate irrigation is not available). Heavy rain at late fruiting will increase problems of diseases on fruits of most if not all crops. Certain crops like corn, kidney beans will either fail to reach maturity or the seeds will start to grow before they are reaped.

   In cases where there are heavy rainfall for 2-3 successive months, the vegetable grower might have to alter his usual planting plans and grow only hardier crops during this period.

Note that in determining the time to plant to avoid planting and late fruiting in heavy rain, both the total rainfall and the way it falls(distribution) are important. Vegetable growers particularly those new to the field, would need to get rainfall figures for the area. Remember that these would be the same ones used in selecting crops so there would be no need to give the agricultural officer extra work.

Where figures are not available for the distribution, then it would be wise to talk with an experienced farmer or any one living in the area to find out how the rain falls. Does it fall heavy through out the whole month or is it at the beginning, middle or end of the month. This may not be as reliable as when figures on available, but can be a helpful guide here.

Let us look at the figures* for Highgate.

(12:6) Total rainfall for each month.

Months	Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
temp °F	79	80	82	83	85	86	87	87	87	86	83	81
rain /in ins.	3.0	2.5	3.0	5.5	10.0	7.0	7.5	10.0	9.5	12.5	6.5	3.0

A smart grower in Highgate would try to organise his planting time in such a way that he does not have to plant or reap any in May, August, September or October. Many times the distribution of the rain may be such that most falls for 2 or 3 weeks between one month and another.

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* Figures for High-gate in Jamaica Temp. figs. converted to nearest whole number•Rain figs. converted ot nearest 0.5 supplied by Palisadoes meterological station. Averages for period 1931 - 1960.

Planting where irrigation is inadequate

While it is best to grow vegetables where irrigation is adequate, in some cases, water is available in limited supply. Sometimes no irrigation is used at all. This is the situation in most areas where peasants grow their crops. In these cases, planting plans should be made to fit completely into the rainfall pattern.

If we look back at the rainfall figures for Highgate we will see that it is best to plant in about late March to get the April, May and June rains. Depending on how much irrigation water is available, the crop could be planted earlier and irrigated in this early stage. Remember that it is bes to try and avoid planting or reaping periods to fall in periods of heavy rain. This might not apply very well in the case where the grower depends totally on rain.

As in planting, a knowledge of the distribution of the rain is very important. It would be best to avoid planting in February. This month could be used for preparing land while crops to be transplanted could be seeded in nurseries.

Where to plant

In furrows - It is best to plant crops in furrows during the drier months of the year. This might not be possible where a mechanical seeder is used for planting. Planting in furrows increase the amount of moisture availabl to the plant. If adequate irrigation is available especially on clay soil, planting should be done on banks.

On banks - Planting should generally be done on banks during the rainier months. This reduces the problem of root rot which is a common disease under rainy conditions. The width of the banks will vary with the soil type and crop to be planted.

C HOW TO PLANT

There are 3 methods that are most widely used in growing vegetables viz.-

1. Direct planting - i.e. seeds are planted directly in the field.
2. Pot planting - i.e. seeds are sown in peat-pots and a seedling in each pot planted in the field.
3. Trans planting - i.e. seeds are sown in a nursery and the seedlings are later removed and planted in the field.

Direct planting

This is the most widely used method of planting vegetables and is used both for planting in rows or for broadcasting seeds. It is best suited for planting large seed that produce large seedlings, but can be used to plant all vegetable crops.

In vegetable production, direct planting is usually done either with a seed-planter or by hand planting. These are by for the most widely used means although in some countries, aeroplanes have been used for this operation.

Using a seed-planter

Seed planters of different sizes are used in vegetable growing. These machines are very helpful to the grower. A large planter is usually attached to a tractor and drawn through the field in planting, while a small one is usually pushed by one person. These equipments can be used efficiently for spacing small and large seeds along the rows. Because of this, when possible, a grower should try to get one for planting his crops. It might allow for planting that will give the best yields to farmers in an area.

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* Direct seeding and direct planting refers to the same thing.

(12:8) Two models of hand-operated seed-planters.

Some seeders can apply fertilizer in bands at the same time that it is planting the seeds. These are the best types for small scale operations. It is important to note that there is another type of equipment that plants seedlings. This is called a planter.

How to use seed-planter

Most of this information will be given by the dealer from which the equipment is bought. After the land is prepared, the required amoun t of seed is poured into containers called hoppers. The plates through which the seeds will pass are adjusted to suit the size of the seed. The amount of seeds and the spacing of the seeds along the row, should be adjusted according to the crop and the percentage germination of the seeds to get the required population. It is usually easier to plant the crop and then thin out, than to have to do later plantings to get the correct population.

Adjustments are made to get the required distance along the rows. IF a large planter is used, it will have more than one hopper for planting the equivalent number of rows at a time. These will have to be adjusted for the required distance between the rows. Most planters open a furrow (the depth can be adjuste)., plant and cover the seed in one operation. A seed planter is a most essential equipment on a vegetable farm and should be used by all farmers. When we look at hand plantings we will see how true this is.

Small farmers in a community should try to co-operatively buy and use a larg planter. This will be less expensive to each and the equipment will be more fully used. Remember this - <u>5 farmers with $20 each might be able to own what each farmer will need but no one can afford</u>

Suggested planting depths:-

Plant large seedling crops at	1-2 ins deep. or 3-5 cm. eg. Corn
Plant small seedling crops at	1/2 - 1 ins deep or 1.5 - 3 cm eg. Lettuce.

Hand-planting

Planting by hand is the older and most widely used method of growing vegetables. It is a difficult method especially for planting small seeds and as such should be replaced by use of seed planters. We should however know how to use this method and where possible, improve it.

Planting in furrows -large seeds that produce large seedlings

1. Open furrows at the required distance between rows. These should be 6-8 ins deep (15-20 cm) if crop is to be grown in furrows, or 3-4 ins deep (7-10 cm) for growing on beds, and should be done at land preparation.

   If a large tractor with a horrow is used in land preparation, planting can be done in each or in alternative furrows to get the correct distance between the rows.

2. Apply fertilizer - i.e. the grade and quantity recommended for the crop at planting,. It shou ld be applied in the furrows and between the rows.

   Treat-seeds and soil if necessary (i.e. pre-plant treatment) for pest control. In cases when seeds were bought treated, it might not be necessary to treat either the seed or the soil before planting. Even then it is best to treat the soil. A recommended insecticide in fungicide might be applied together as sprays particularly directed in the furrows or as powder. Some equipments called dusters, can be used for applying the powder.

   (See seed and soil treatment for each crop in Sect. 5 for more on dusters)

3. Cover the fertilizer at 1-2 inch deep (2-5cm). If seeds are planted so as he touch the material, either the seeds itself or the young seedling will be damaged after germination.

4. Drop the seeds at the required distance along the rows. This will not be as accurate as if a seeder was used. However, with practice a grower will find that he comes fairly near to the planter. Every effort should be made to keep the population at the required level.

5. Cover the seeds at the depth recommended for each crop. On lighter soils, seeds might be covered deeper than on heavier soils especially where irrigation or rain is limited. However, this depth should be kept within the recommended range for the crop.

6. Irrigate the field when planting is completed. If planting was done in moist soil, it might not be necessary to irrigate the field. But generally, it is easier to plant seeds in dry soil and later water the field.

Planting seeds that produce small seedlings

1. Open shallow furrows 1-2 ins deep on beds. It is not recommended to plant these seeds in deep furrows as rain or irrigation might bury them with soil to a depth that will markely retard their progress. If moisture conditions make it necessary to grow them in furrows, it is best to transplant those crops suited. A wheel hoe might be useful in opening shallow furrows.

2. Apply fertilizer i.e. recommended rate and grade for the crop. It is best to apply the fertilizer in bands on both sides of the furrows.

3. Pre-treat seeds and the soil where necessary for pest control.

4. Make a mixture of sand and the required quantity of small seeds. This is not necessary for large seeds. The ratio of seed to sand in the mixture would depend on the distance along the row that the crop is to be planted. Here again the grower has to develop his own technique. However, a mixture of 1 part seed to 15-20 parts sand (eg. 1 oz seed to 1 lb sand) would be suitable for most distances between 2-6 ins,5-15 cm) along rows. Remember crops like cabbage, seeds will be planted somewhere in this range and later thinning will be done.

5. Sprinkle the mixture lightly along the furrow. The greater is the required distance along the rows, the lighter should the mixture be sprinkled. It is best to spread the mixture across the width of the furrow. This gives better spacing of the plants than if it is spread in a narrow line along the furrow. Try to get an even distribution of seeds.

6. Cover the mixture at the recommended depth for each crop. Irrigate the field when the job is completed. From looking at this whole operation we should now see why a seeder is so necessary on the farm.

7. Planting in holes. Peasant vegetable growers plant most of their large seeded crops in holes. The land is usually ploughed, harrowed and holes are dug at the required distance along rows. A hoe or a machete is the tool most often used. This way of planting is slower than if machinery is used for opening furrows and is also tiring to the farmer. The result is the speed at which peasant farmers become old with pains in every part of their body. For these reasons, such operations should be kept at a minimum in modern agriculture. As much and as soon as possible peasant farmers should try to use machines to open furrows for planting instead of having to plant in holes.

Here are some suggestions that should help to reduce the pain.

1. Avoid digging wet soil, If the farmer wants to plant to catch the rain, if the land is level, open the holes wide a few days before the rains are expected. Well what about the unexpected rain? Wait a day or two after when the soil is still moist but not wet. Peasants are usually so glad for the rain that the rain falls one night and the following morning they are planting.

2. When a crop can be planted at two seeds per hole without marked reduction in yields, do this. It reduces the number of holes needed. However, planting 4 and 6 seeds in one hole is a dreadful practice. This reduces yield per acre despite the fact that many peasants believe the opposite.

3. Small farmers in a community will always benefit by co-operation. Where it is possible, if a large seeder cannot be afforded, 2 or 3 hand operated ones could be bought to do the planting in the community.

Planting in rows vs Broadcasting.

Most vegetable crops are presently grown in rows, but some of these same ones could also be successfully grown by scattering the seeds (broadcasting) over the ploughed land. Here are some crops that will give fairly good results when broadcasted. They will do best when grown in cool areas.

Beet
Carrot
Chard
Chinese cabbage
Mustard
Parsley
Radish
Rutabaga
Turnip

The main advantages of planting in rows are the ease of movement in the field for weed, pest control and harvesting. There is also a better distribution of seeds at planting, However, broadcasting also has its good points. These include the ease of planting the crop and the higher populations that will still allow good yields.

The main set-backs with broadcasting is the difficulty of moving in a field, the problem of removing weeds and the need for more moisture for germination and early growth.

How to broadcast seeds

1. Prepare raised beds of not over 5 ft (1.5m) in width.

2. Apply fertilizer to the beds by broadcasting.

3. Treat the seeds and soil if necessary.

4. Scatter the seeds at the required rate on the beds. About 1 1/4-1 1/2 times the amount for planting in rows should be used.

5. Rake the seeds into the soil enough to cover them. Rake backward and forward to avoid heaping the seeds.

6. Apply a pre-emergent weedcide. This will reduce if not eliminate the problem of weeds. The foliage of the crop at that high population and the way the crop is planted will help to suppress the weeds.

<u>Direct planting</u>

Good points.

1. The crop matures more quickly than with other methods if weed control is good and sufficient water available.

2. Usually less costly than other methods.

Problems.

1. There is a need for more water for germination and early growth.

2. With small seeds that are planted by hand, seeding tend to be too thick in parts and too sparse in other areas.

3. There is a need for more rigid pest control over the whole field.

4. There is a need for thinning out a seedlings if seeds were planted at a population above the one required.

5. A more rigid weed control is necessary. The weed seeds which were in the soil before planting in most cases starts to germinate before the crop. The result is that the weeds start ahead of the crop and competes for nutrients and sunlight. If care is not taken especially with small seedlings, in a short time, the crop will be almost eliminated.
When we come to weed control we will see how to tackle this last problem.

Thinning seedlings.

The main purpose of thinning out seedlings is to get the plants at the required distance along the rows. In this the weaker seedlings are pulled up in such a way that the more vigourous ones are left at the distance required along the row. For most crops, thinning is done at the 4-leaf stage. Generally, more than the required seeds might be planted to compensate for poor germination and to enable selection. For example, 3 seeds might be planted in a hole where 2 plants are required. The weakest plant would be thinned out. The young plants removed are either discarded, transplanted to places where the population is below that required or planted in already prepared land. Try to avoid excessive thinning which will result in population below that required.

Thinning is a job that consumes much time as care must be taken not to damage either the root system or shoot of the plants that will be left in the field. For the vegetable farmer this means increased total expenses which increases directly with the amount of thinning necessary. So that the less thinning the farmer has to do, the better it is for him within certain limits. It is good to plant more than the required number of seeds to have a chance to select the more vigourous plants for production. But there is the problem of competing seedlings and the cost of thinning. Try to do all the necessary thinning once.

In summing up

1. Thinning is necessary where young plants are at a distance along rows that will give a population above the required one.

2. Remove weaker seedlings at 4-leaf stage, leaving the more vigorous ones at the required distances.

3. Avoid excessive early thinning.

4. Try to keep thinning at a minimum in a single operation as it is an expensive job.

(12:9) a. Crop before thinning b Crop after thinning.

POT PLANTING

Pot planting is the method least used in planting vegetables. This is due mainly the fact that most growers do not know about and its use is fairly costly. In this, small pots made of peat (the same material that form the large part of peat soils), are filled with soil and the seeds planted in it. Later the seedlings still in the pots (1 seedling per pot) are planted in the field. Pots of varying shapes and sizes can be used for growing crops that are usually transplanted. Pots of approx. 2x2x2 cubic inches will be suitable for crops to be planted at the 4-leafy stage. These pots can be bought from dealers in agricultural supplies.

How to plant with peat pots.

1. Get an amount of dry refined soil enough to fill the number of pots to be used. A mixture of soil and sand can also be used where regular watering is to be done.

2. Pre-treat the seeds and soil if necessary. It is better to use the pesticide (insecticide and fungicide) in the powder form.

3. Fill each pot with soil.

4. Plant 1 or 2 seeds in each pot depending on vigour and %G shown from test of the seeds. A small bit of stick can be used to open the hole (approx. 1/2 inch deep) in which the seeds will be planted.

   OR, the pot can be half filled with soil, the seeds put in and then the pot is completely filled. Because the seeds are so small, although the grower wants to put only one to a pot, if 2 or 3 accidentally fall in a pot, time should not be wasted to try and take this out. What might happen is that the seed sink further in the soil, which will delay emergence.

(12:10) a. Top-peat pot of different sizes and shapes.

b. Below-lettuce and tomato seedlings ready for planting in pots.

5 Set the pots either in the open or shade them. A shed can be used for small operation or under fine mesh for large operations. Do not put pots under a tree as this creates problems of hardening the seedlings and damage when rain falls. Shading allow the seedlings to grow faster, but hardening (i.e. gradually allowing the plant to adjust to field conditions) is necessary. This is not needed if pots are put in the open.

6. Water the seeds with a starter solution weekly and apply regular watering about every 2 or 3 days depending on the rate of water loss from the pots. The starter solution should be weak as stronger solution either destroy seedlings when they germinate or force growth. The seedlings would then grow quickly but would be flabby, generally lack vigour and will not do well when planted in the field.

Remember if by mistake too strong a fertilizer solution is applied, as soon as it is noticed, add excess water to the nursery. A watering can, a hose with a nozzle or a pipe from a regular water supply can be used to water the nursery.

(12:11). Light sprinkler and watering can

7. If necessary, thin out seedlings 1-2 weeks after emergence leaving the most robust in each pot.

8. If pots were put under sheds, start to harden the seedlings about I-10 days before they are to be planted in the field. How?

   (a) Reduce the water supply.

   (b) Remove covering from shed gradually. This should be completed to allow the seedlings not less than 3 days full exposure to direct sunlight before it is planted.

9. Start preparing the land a few days before the crop is to be planted. Furrows 4-6 ins should be opened at the required distance apart.

10. Apply fertilizer to the field. Adequate amounts should be placed in the furrows. It is not necessary to cover the fertilizer.

11. The seedlings would be ready for planting at the 4 leaf stage and by this,roots would start growing through the pots. i.e. 4-6 weeks from sowing). Transport the pots with the seedlings to the field and plant them in the pot at the required distance along the rows.

12. Irrigate the field as early as possible.

(12:12) <u>Drawing of seedling at 4-leaf stage with roots growing through pot.</u>

<u>Good points in using peat pots</u>

1. The problem of high amount of water required for germination and early growth in direct planting is eliminated. Only a small amount of water is needed to wet the seeds and seedling in the nursery. At planting, in the field the pot acts as means of reducing loss of water around the roots.

2. The problem of the young plants competing with weeds for nutrients and light is reduced. The seedlings in pot are ahead of the weeds.

3. The crop reaches maturity earlier than when they grow from transplants. This is because in pots, the seedlings are better spaced in the nursery and could grow better. In addition they do not suffer from the set back that crops face at the time of transplant. Remember that saving a week or two reduces expenses and increase the number of crops that can be grown over a period.

4. The plant part eaten is more uniform in size. This is also as a result of the better spacing of the seedlings in the nursery. Uniformity of plant parts is a very important factor when these parts have to be graded. Generally as uniformity increase, the easier it will be to grading the crop.

5. Peat pot planting is a easier method of planting small seeds, than either transplanting or hand-planting of seeds. The result is that <u>the actual cost of planting</u> might be less than these two. In addition, apart from a small amount in the nursery, the need to thin out the crop is wiped out.

6. The crop stays in the field for a shorter period so that more crops can be grown in a year than from direct seeding. For example, a crop of lettuce might take 10 weeks to maturity. With peat pots and transplanting about 1/3 of this time might be spent in the nursery.

<u>Problems in using peat pots</u>.

1. In later growth, it is necessary to apply more water than in direct planting. This is so as the peat pots should be broken down by then. If not it will impede the development of roots and reduce growth and production.

(12:13) <u>Pot still intact after fully grown plants pulled up</u>.

2. The greatest problem in this method of planting, is in the initial cost of buying the pots and planting the seed. Although it takes much less time than direct hand-planting, it takes more than transplanting.

So that although it has so many good points its initial cost <u>might</u> make it less profitable than direct and transplanting.

D. TRANSPLANTING

Transplanting is the only method used by most small farmers to plant certain crops. For instance some farmers have never used any method other than transplanting to grow nearly all leaf crops. However, some are now experimenting with the two other methods particularly direct planting with seed-planters,

Crop response to transplanting

Remember we said that all crops can be successfully grown from direct seeding but this is not so with transplanting. All crops can no doubt be grown from transplants, but for some crops it is very difficult. The vegetable grower should avoid growing the difficult ones (i.e. crops with poor response) from transplanting.

(12:14)

Here are some vegetable crops and their response to transplanting.

Good	Fair	Poor
Brocolli	Chinese cabbage	Beans
Brussels spout	Chard	Beet
Cabbage	Cucumber	Carrot
Cauliflower	Muskmellon	Corn
Celery	Okra	Cow-pea
Egg-plant	Spinach	Mustard
Onion	Watermellon	Potato
Lettuce		Radish
Pepper		Turnip
Parsley		
Tomato		

How to grow seedlings for transplanting

1. For the nursery, plough up the area required to hold the number of seedlings. Seeds should be put in rows about 4-6 inches apart or broadcast to allow about 1-2 inches apart depending on the size of seedlings. Refine the soil to make the seed bed before it is ready for planting.

2. Make raised beds about 3-5 feet wide with walking space between the beds. These should be relatively flat, but arranged to allow good drainage.

3. Treat the seeds and the seed beds if necessary. (see pest control) with an insecticide and fungicide mixture.

4. Make a mixture of seed and sand in about a 1 to 10 ratio if seeds are very small. This enable a better distribution and reduce crowding.

5. Scatter the mixture across the width of the seed bed or in shallow farrows and cover it lightly with soil sprinkled to a depth of about 1/4 inch (less than 1 cm).

6. Water the bed with a fine spray of water or a watering pan.

7. Cover the beds with plant material (dry grass, coconut bough) after planting or fine mesh in larger scale operation. After 3-4 days the seedling should start emerging and the plant material removed. It encourages insects and keep off sunlight. The seedlings can be sprayed if there are signs of insects.

8. Water the seeds with a starter NPK solution about once per week and in addition apply water each 2 - 3 days as is required.

9. If necessary, thin out weak seedlings to reduce crowding. This should be done 1-2 weeks after emergence

10. Start preparing the land in time for planting. Make furrows 4-6 ins. deep at the required distance between the rows. Apply fertilizers recommended at planting, making sure that adequate amounts are applied in the furrow. Cover this about 1/2 inch deep to prevent the root of the young plant from touching it.

11. Carefully remove the seedling from the nursery at the 4-leaf stage (usually 4-6 weeks after sowing) and carry them to the field. A hand fork should be used ot loosen up seedlings in removing them so as to reduce root damage.

12. Drop the seedlings at the required distance along the rows and plant them. Planting is best done in the afternoon to allow seedlings to recover to some extent during the night.

13. Irrigate immediately after the job is finished. Where water is limited, individual plants should be watered instead of trying to water the entire surface of the field.

(12:15) (Top) Seedlings in nursery

(Middle) Dropping seedling in furrows

(Bottom) Planting the seedling.

Good points in transplanting.

1. Less water is required for the first 4-6 critical weeks of growth. As the seedlings are in a smaller area, it takes less water to wet the nursery than when planted in the field. For example, a square chain (400 sq. m) of pepper in a nursery might supply enough seedlings to plant as much as 200 sq. chns. (.8 ha) in the field. A sq. chn. of tomato would be able to set as much as 230 sq. chns (9 ha). This means that in both cases, the same amount of seeds directly planted in the field would take more but not less than 500 times the amount of water when grown in a nursery for the same period. However, for about the first week after transplant, more water has to be applied than when the crop reach this stage from direct seeding.

2. Plants when set in the field have a head start over weeds and the crop might be way ahead before weeds become a serious problem. Controlling weeds in the nursery is not a serious problem. Pest control is also easier.

3. Crops spend a shorter time in the field enabling a larger number of crops to be grown in a given period.

Problems in transplanting

1. In removing the seedlings for transplanting, some damage is done to the roots and/ it takes time. to adjust to a few home, the plant is set back. This is why in this method crops usually mature later than with the other methods where water is available.

2. A disease affecting a new plants is more quickly spread as the seedlings are so near to each other. Quite often when a disease sets in, the whole nursery is quickly destroyed. However, if the disease or pest is seen early. spraying may help to check the spread of the disease or pest in the nursery.

3. If the seedling are poorly spaced in the nursery or damaged while being removed for planting, the plants will give poor yields.

(12:16) Cabbage grown from poorly spaced seeding (right) gives poor yield.

Moisture needed for germination

Seeds of all crops when planted need moisture in the soil for them to germinate. However, different crops require different minimum levels of soil moisture i.e. the smallest amount of water in soil that will allow germination. It is important for growers to note that all seeds will germinate quicker within a range as soil moisture increases up to field capacity. (Table12 18 gives the range of days to emergence)

(12:17) Here is the minimum level of soil moisture needed by some vegetable crops to germinate.

Slightly moist soil - (i.e. low minimum soil moisture) requirement - 15 to 20% above permanent wilting point.

Cabbage
Corn
Muskmellon
Pepper
Radish
Squash
Turnip
Watermellon

Moderately moist soil - (i.e. medium minimum soil moisture) required 20% above permanent wilting point)

Bean
Carrot
Cucumber
Onion
Spinach
Tomato

Very moist soil - (i.e. high minimum soil moisture) required > 50% above permanent wilting point)

Beet
Lettuce
Celery

Days of emergence of seedlings

After planting, the seedlings of different crops take different times to germinate and emerge above the soil surface. The length of time a seed takes to emerge will depend on -

1. Length of time to germinate i.e. seeds of different crops take different length of time to germinate. Generally the quicker the seed germinates, the shorter time the seedling takes to emerge (and visa versa.)

2. Level of soil moisture - i.e. the more moisture up to a point in the soil, the faster the seed will germinate and the seedling emerge
But the extent to which this will happen depends too on the type of seed. eg. at the same level of moisture in the soil, corn will germinate more quickly than celery.

3. Planting depth i.e. the deeper the seed is planted, the longer time the seedling will take to emerge.

4. Soil texture - i.e. the lighter the soil, the faster the seedling will emerge if moisture is adequately supplied.

5. Temperature i.e. the warmer the soil the quicker the seed will germinate and the seedling emerge.

The vegetable grower should know the days to emergence of his crops. With this, he would know what to expect. Example - A grower planting beans would know that his crop should emerge within 10 days, and if this does not happen, he would know that something is wrong. But if he planted pepper, he would know that he might have to wait 2 weeks for the first sign of his crop.

(12:18)

Here is a table with information on emergence, transplanting and reaping for some vegetable crops.

Crops	Approximate time to		
	emergence (days)	Transplant (wks)	1st. reaping* (wks.)
Beans (snap)	5- 8 days	-	7-10
Beans (lima)	5-10 "	-	9-12
Beet	4- 6 "	-	8-12
Brocolli	5- 8	-	10-16
Brussel sprout	4- 8		12-16
Cabbage	4- 7	4- 6 weeks	12-16
Calaloo	4- 6	2- 4	7- 8
Carrot	6-10	-	8-12
Cauliflower	4-10	4- 6	8-14
Celery	7-15		12-10
Chard	4 -6		7-10
Corn	4- 7	-	10-15
Cucumber	4- 7	-	7-10
Endive	2- 4	-	12-14
Eskellion	4- 7	3-5	10-14
Garden egg	5-12	4-6	10-14
Kale	4-7		8-12
Kohl-rabi	5-7		8-10
Leek	5-8		14-16
Lettuce	4-7	3-5	10-12
Muskmellon	4-8	-	12-16
Mustard	3-6	3-5	7-10
Okra	7-15	-	7-10
Onion	4-7	3-5	12-16
Parsley	12-15	-	10-12
Parsnip	14-19	-	12-16
Pepper	7-14	4-6	9-14
Peas	5- 8	-	8-12
Potato	7-14	-	12-14

* Time to the first reaping includes the time spent in the nursery.

Crop (contd).	Approximate time to -		
	Emergence	Transplant	1st reaping (weeks)
Potato	7- 14	-	12-14
Pumpkin	5- 12	-	14-16
Radish	3- 6	-	3- 6
Rutabage	3- 6	-	6-10
Spinach	5- 7	-	5- 9
Squash	5- 12	-	8-12
Tomato	5- 12	4 6	10-14
Turnip	3- 6	-	6-10
Watermellon	5- 12	-	10-14

Note - that time to first reap will vary with the variety and with soil and other conditions in different areas. These figures are for the majority of commonly grown varieties from planting the seeds.

E. MULTI - PLANTING SYSTEM.

The market problems

In many tropical countries at certain times of the year, vegetable is in short. supply and sells for a fantastic price. At other times, sometimes a week later, it is in such abundance that the price is very low and the farmer looses money. One week tomato will sell at 30¢ per lb and 15¢ the following week. If he is not kind enough to give it away, he carries back home (increasing his expenses) and feeds it to hogs.

The reason for this is that most farmers in an area plant their crops at the same time of the year and reap it at the same time. The time when there are only a few farmers reaping, the supply is low, the price is high and most housewives still cant get the crop that their hearts are set on. On the other hand, the time when most farmers reap their crop is the time when the price is low and housewives have enough to pick up, squeeze up and refuse. The hogs get them then. This problem is due partly to the economic organization of these countries. In addition, most farmers have to depend totally on rainfall and do not know how to plan their planting. A way to tackle this problem would be to have the reaping of crops spread over a longer time and have a more constant supply for market. This will benefit farmers who do not have irrigation water, but more so, those with adequate water for irrigation.

How to apply multi-planting - This system of planting and the"out of season production" resulting from it, is designed to be of help both to the individual vegetable grower and to the community at large.

The individual grower must be certain that market is available, for this type of reaping. A contract market is most suited. In this planting pattern, the number of plantings of each crop is increased and this has the effect of increasing the number of times a crop is reaped for the year. If seasonal conditions are correct and moisture supply is adequate, it is possible to reap a crop right throughout the year. However, more often the number of reaping is increased and harvesting is spread more evenly. Normally multi-planting does not increase the total yield from a given area. However, it ensures that grower gets a better selling price for his product as he produces at times when there is little supply on the market. It might also be possible to reduce labour cost.

Also note the following:-

- irrigation must be available to use multi-planting effectively.
- the grower should have machinery available which he needs particularly for land preparation.
- if all the grower in an area use a multi-planting, the benefit from the system does not go to a single farmer, but to the whole community i.e. grower and consumer. This is because prices would be more stable for the grower, while the consumer would get a steadier supply of vegetables.

Example -

Here is a model of a multi-planting plan for growing two crops. We will use corn (3 months duration) and watermellon (4 months) to show how the system works.

(12:19)

Planting & reaping pattern	(1)	(2)	(3)	(4)	(5)	(6)
	C_1	C_1	C_1	C_1	C_1	C_1
1st plant	1st wk Jan.	3rd wk Jan	1st wk Feb.	3rd Wk Feb	1st wk Mar	3rd wk Mar
1st reap	1st wk Apr	3rd wk Apr	1st wk May	3rd wk May	1st wk Jun	3rd wk Jun
	C_2	C_2	C_2	C_2	C_2	C_2
2nd plant	3rd wk Apr	1st wk May	3rd wk May	1st wk Jun	3rd wk Jun	1st wk Jul
2nd reap	3rd wk Aug.	1st wk Sept.	3rd wk Sept	1st wk Oct.	3rd wk Oct.	1st wk Nov

Planting & reaping pattern	(7)	(8)	(9)	(10)	(11)	(12)
	C_2	C_2	C_2	C_2	C_2	C_2
1st plant	2nd wk Jan	4th wk Jan.	2nd wk Feb	4th wk Feb	2nd wk Mar	4th wk Mar
1st reap	2nd wk May	4th wk May	2nd wk Jun	4th wk Jun	2nd wk Jul	4th wk Jul
	C_1	C_1	C_1	C_1	C_1	C_1
2nd plant	4th wk May	2nd wk Jun	4th wk Jun	2nd wk Jul	4th wk Jul	2nd wk Aug
2nd reap	4th wk Aug	2nd wk Sept	4th wk Sept	2nd wk Oct	4th wk Oct	2nd wk Nov

C_1 = corn C_2 = watermellon

In the above example -

1. The field is first divided into 2 sections and then sub-divided into 6 plots for each crop. In the first planting, corn is planted in plots 1-6, and watermellon planted in plots 7-12.

   It is important to note in the first that the sections do not have to be o equal sizes. If at the early part of the year there is a great demand for corn, then section A should be bigger than B. So that the size of each section should depend on the market demand at a particular time.

In addition the plots within a section do not have to be of equal size. If for example, a grower know that prices in June is particularly good, then in the example, he could make plots 5,6, 9 and 10 larger than the others. At other times, he might have one crop in one section, and 2 crops sharing the other section.

2. The land preparation and planting would then commence. Here corn would be planted in plot 1 in the first week of January, and reaping from this planting would be completed by the 1 st week in April. The following week, watermellon would be planted in plot 7 and reaping from this planting would be completed by the 2nd week in May. The 3rd week, corn would be planted on plot 2 and so on.

When reaping from the 1st planting of corn is completed, then watermellon will not be planted on this same plot. According to the model, this would be done in the 3rd week of April. Reaping from this 2nd planting would be completed by the 3rd week of September. Similarly, when reaping of the first crop of watermellon in plot 7, corn will then be planted in- this plot. Reaping would be completed by the 4th week in August. A 3rd planting could start in September on plots 1 and 7.

We should note that for the second (and later) planting it is <u>not</u> necessary to use the same crops. For example, if prices for watermellon is low going to the end of the year then another crop which suits market and other requirement should be planted instead. Other requirements would include how well the crop is suited for the seasonal conditions at that time of the year. If corn for instance, will not grow well in the later part of the year, then, it would not be planted a second time. So that what we may well have is a situation in which the grower plants corn and watermellon in the early part of the year, and two different crops in the latter part.

We should also note that to a certain extent, the system will satisfy the need for rotating crops. Later, different system of rotation will be suggested, and it might be difficult to fit a perfect rotation pattern into a multi-planting system. The grower should not worry too much about this as it is not advisable to try too hard to get the best of two worlds, we might end up getting the worst both.

3. The model shows a difference of 2 weeks in planting 6 plots in each section. The grower could reduce this interval to a week or increase the number of plots to suit his requirements. Note that the greater the planting interval, the more widely the reaping is spread. The same holds for number of plots in that, the more plots the more widely planting will spread.

4. From looking at the example it would appear that the land has to be unoccupied to start planting. This does not have to be so. We see from the model that while plots 1,2, 7 and 8 will be planted in January, plots 5,6, 11 and 12 will not be planted until March. All this means is that the grower who is going to do multi-planting for the first time, should make his plans in such a way, that the land will not be occupied when he is ready to start planting. If he had tomato which is 4 weeks old in plots 5, 6, 11 and 12, he could not start planting in early January. He would have to wait at least 3 months (in April) before the tomato would be completely reaped. So that if he started to plant in January, he would find that when he is ready to plant these plots in March, tomato would still be on them

   What he would have to do is to start his planting in February so that by the time he is ready to plant plots 5,6,11 and 12, the tomato would have been reaped.

   Note that this problem prevents itself only when the system is being used for the first time. Later when the system is working, this problem is no more. For example, we see that when watermellon is being planted in plot 1 (2nd planting in 3rd week April plots 3-6 would still be occupied with corn,

5. The above example is a model and nothing more than a model. What this means is that if a grower were to plant two crops following this plan and expect to reap them as shown, he would be dissapointed. Certain times, he would find his crop ready for reaping one to two weeks early, while at another time, it would be late. In addition different varieties take different time to be ready for reaping.

All this rigma-role is merely to say the thing that has been said a thousand times before. i.e. The grower should use the above model only as a guide at different times in planting his own multi-reap system.

(The model is for two crops, to make it simpler to explain the system.)
(However, multi-planting can be used on any number of crops.

(12:20) Okra growing from multi-planting.

Chapter 13. IRRIGATION AND DRAINAGE

A. IRRIGATION

Vegetables get water by 2 means viz -

- rainfall i.e. natural means of applying water.
- irrigation i.e. applying water by means other than from rain.

Irrigation - For vegetable production irrigation often is essential. The extent to which it is needed will depend on the rainfall in the area as irrigation is really a supplement to rainfall. The more rainy the area, the less irrigation will be necessary. In a very few cases, it is possible to produce on a large scale without irrigation. However, even in many of these cases, production would be increased if irrigation water was applied.

Rainfall - This has 2 features of importance to the vegetable grower viz -

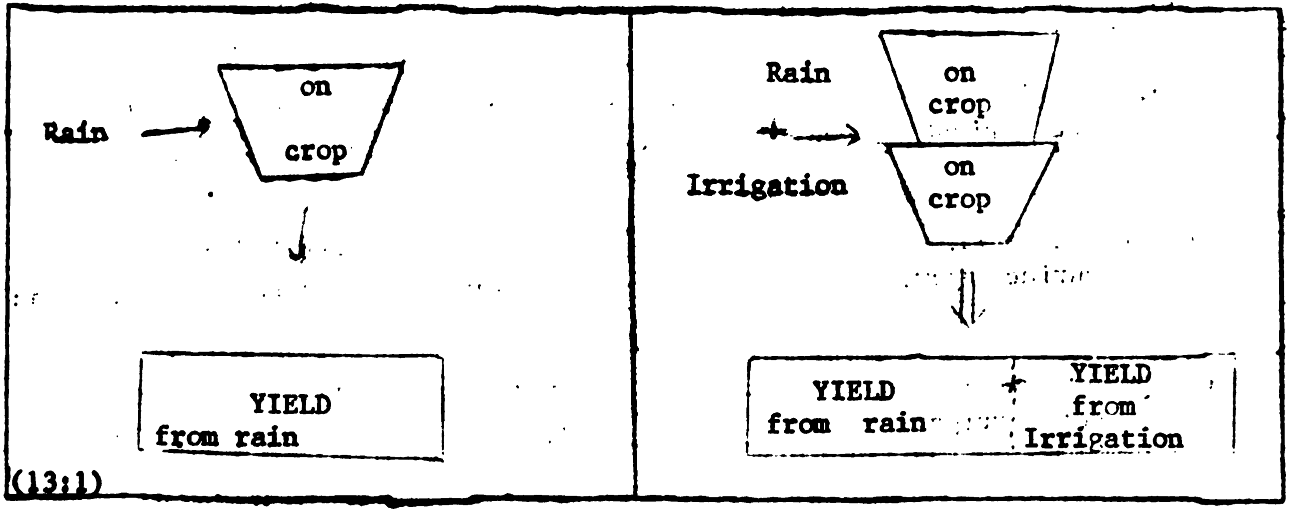
1. **Total rainfall** - i.e. amount of rain for a period (month, quarter, year).

2. **Distribution of rainfall** - i.e. the way the total rainfall is spread over the given period.

If we look back at the rainfall figures for Highgate for Aug - September in Table 12:6, we will see the two features and the way they are important. Because, it is good to have a total of 7" or 8" of rain for a month, but when 3" or 4" fall in the last week of the month, what happen to the crop in the first 3 weeks? It suffers if irrigation is not used during this period. One of mans greatest problem is how to control nature. The vegetable producer can control neither the total rainfall or its distribution and because it is rare that both of these factors suit the grower, irrigation becomes almost essential in vegetable production.

Water must be available in adequate supply for all vegetable crops to realise maximum growth and yields.

Look at the illustration below and say what you understand from it.



(13:1)

Irrigation vs rainfall

1. With irrigation, vegetables can be planted in almost any area at any time of the year. The grower does not have to wait for a certain time when rain is adequate for germination of seeds and for growth.

2. Fertilizers can be applied in the irrigation water. This is propably the least expensive way to add nutrients to soil and is not possible with rainfall.

3. With irrigation

- overall growth is faster. i.e. Growth both in periods of much rain and periods of limited rain.
- the quality of the plant part eaten is better i.e. fruits , leaves, roots .
- yield usually increase compared to when the crop is grown from rainfall only under the same soil condition and cultivation practices

(13:2) (13:3)

(Left) ____________ growth from rainfall only. (Right) _____ growth from rain and irrigation. Both fields were planted at about the same time.

Methods of Irrigation

Irrigation water is usually applied in one of the following 3 ways:

Surface irrigation - in which water is applied directly on the surface of the soil.

Sub-surface irrigation - in which the water is applied below the soil surface.

Overhead irrigation - in which the water is applied in a fashion resembling rainfall.

Although each method can be used for most conditions existing on a farm, the one most suited will depend on among other factors:

1. slope of the land - eg surface and subsurface irrigation becomes less and less suited as the slope of the land increases.

2. crops to be irrigated and stages of growth - eg. in later growth of corn, if the sprinklers are not very high, overhead irrigation is usually not suitable. At this stage, it does terrible damage to the leaves of the crop as the leaves tend to block the water coming from sprinklers. This also prevents proper distribution of the water over the entire field.

3. available water supply - eg. a canal, nearby stream or pond with water must be present before the grower can use surface irrigation. In addition, this source must be available during most if not the entire duration of the crop.

4.	ability of soil to absorb and hold water (closely related to soil type).	- eg. if the soil does not absorb water easily, it is difficult to use sub-surface irrigation.

Of the 3 methods, overhead irrigation is best suited to a wide range of conditions. However, despite the method, control of the amount of water and the rate at which it is applied (length of time), is important for efficient use of the method.

SURFACE IRRIGATION

Surface irrigation is usually done in 2 ways viz -

- by flood irrigation and - by furrow irrigation.

Border irrigation

This is the most commonly used type of flood irrigation. In this, the field is divided into a number of strips varying from 30-50 ft (10-15 m) in width and as much as 1000 ft (300m) in length. Each strip is surrounded by low dikes (or borders) on either side which separates it from the next strip. The field is so arranged that the length of the strip either run in the direction of the slope or along the contours.

(13:4) water supply (canal)

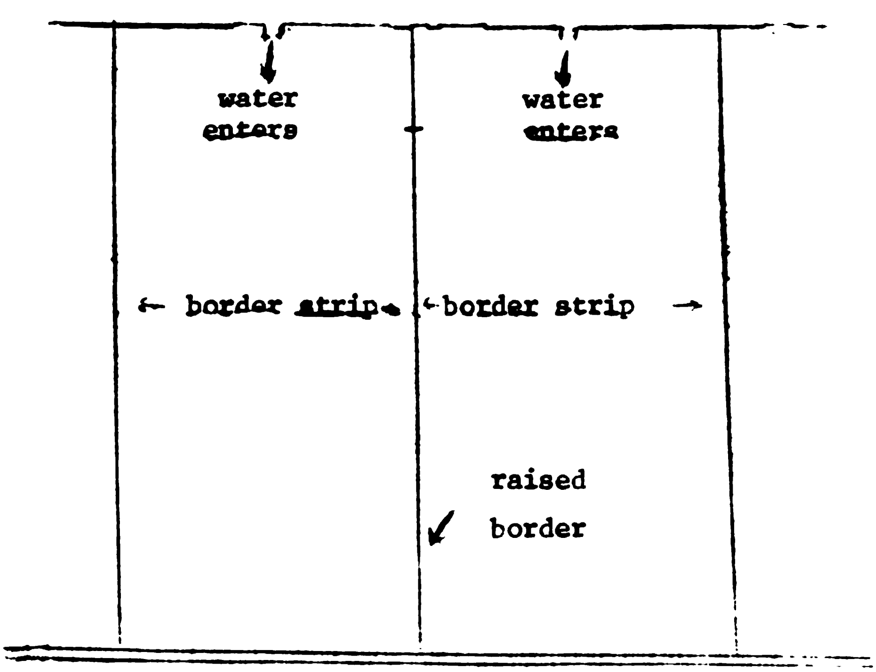


Diagram illustrating border irrigation

Border ht. - 6 - 9 ins. high. (15-13 cm).

Strip width - 30 - 60 ft. (10-20 m)

Strip length- up to 1000 ft (300m) depend on length of land.

The above diagram illustrates border irrigation. It is often used in irrigation of pastures and for growing rice, but least suited for vegetables.

1. Flooding the field for long periods wash off sprays used to control pests.

2. Diseases and insects are rapidly spread in the irrigation water. In this method a part if not the whole of all plants on the strip are covered with water. Pests will be easily transmitted from infected to healthy plants.

Furrow irrigation

This is the most widely used type of surface irrigation in growing vegetables. In this, the water is diverted from a main canal into furrows between the plant beds. Sometimes the water is made to enter the furrows by making openings in the bank of the main canal.

A syphon made of aluminum or plastic can be used for the purpose. Here it is not necessary to break the canal and the water is better distributed throughout the width of the field. Remember that the cost of the syphons would increase total expenses.

(13:5)

Diagram illustrating use of furrow irrigation.

In preparing land for furrow irrigation. -

1. Level the land in the direction of the slope to allow for easy movement of water in the field.

2. Open the furrows in the direction of the slope on slightly sloping land. For greater slopes, open the furrows along the contour. This is important because as the slope increases, the faster the water runs through the furrows. This cause erosion, which might cause the water to cut through the banks and result in some areas not being irrigated.

The distance between furrows - should depend both on the crop to be planted, the soil type and the slope of the land. i.e.

(i) The greater the slope, the nearer the furrow should be. Water will flow more quickly and soak into the soil much more slowly. ie. infiltration will be lower, so more furrows are needed.

(ii) The lighter the soil type the wider should be the beds hence the greater the distance between the furrows. This is important as the water will soak more rapidly into lighter soils (ie. the lighter the soil the higher the infiltration rate). If beds are wide and the water soaks slowly, it will take more time to irrigate the field than with narrower beds. The longer the time taken, the more water running in the furrows will be wasted as the infiltration rate reduces with time.

Furrows should be nearer for heavier soils (2-3 ft. or 2/3 - 1m) and they should be further apart for lighter soils (3-5 ft or 1- 1 2/3m)

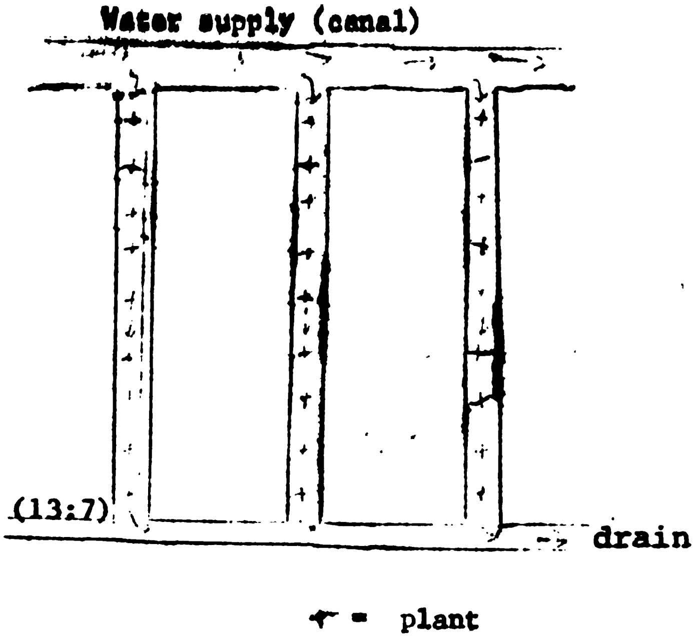
(iii) The distance between furrows should be adjusted also to suit the planting distance required between the rows for the crop to be irrigated. The water would run in the furrows which have to be between rows.

(13:6)
Field being watered by furrow irrigation.

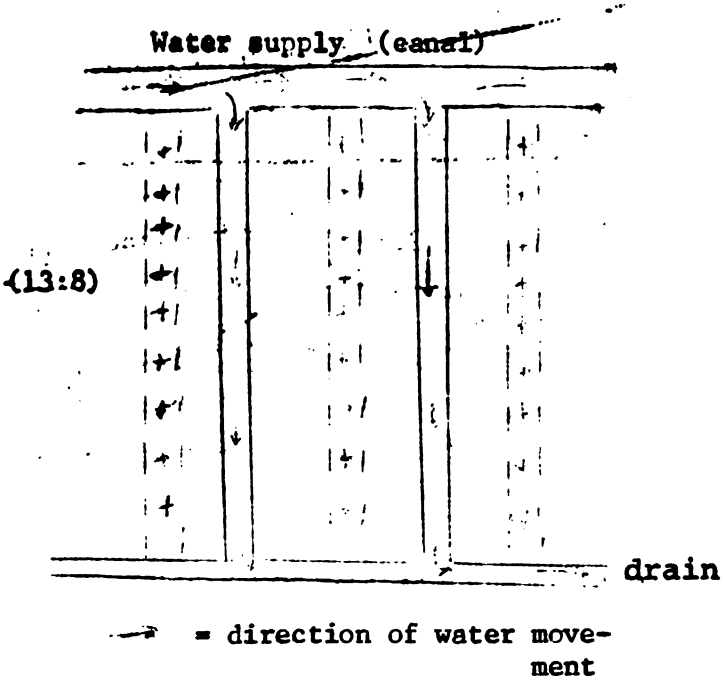
Shifting furrows.

Sometimes it is necessary to transplant a crop in the furrows and to use these furrows also for irrigation during early growth. The grower must have full control over his water. Only a small stream of water at a slow speed can be allowed to run in the furrow as the water can easily dig up the crop. For reducing the speed of water, low barriers of plant material (eg. grass or bits of wood) can be placed at certain distances across the furrow. Later as the plants grow, the furrows has to be removed as the plants will now block the water. The water will gradually dig plants out of the soil when this happens.

Here is a way of shifting furrows:-



A. In early growth, the crop is planted in the furrows and the water also flows in the furrow.



B. In later growth the crop is molded and water now flows in a furrow between rows of the crop. (The dotted lines show the position of furrows in early growth).

Low pressure pipe-line irrigation.

This is a variation of furrow irrigation in which large pipes carry the water from the main canal to the field to be irrigated. The water may or may not be pumped in the pipe line depending on the slope of the land. The pipes are made of light material. (i.e. metal or plastic,) 20-30 ft. long, approx. 6 inches in diameter with openings along its length. The lengths can be connected to each other. The vegetable grower should buy pipes to suit the distance between the rows of his crop. As these distances will be different for some crops, sometimes it is necessary to put water not in each row, but in every other furrow.

(13:9)

Low pressure pipe-line irrigation.

Important points.

1. Initial costs to buy pipe-lines will be high.
2. The need for ditches and the cost of preparing these, is reduced.
3. Pipe-lines make irrigation more efficient as less water is wasted.

DRIP IRRIGATION.

In drip irrigation, water is applied directly to the root of each plant in the field. The water is applied very slowly through small holes along pipelines called drip-lines laid on the soil surface, along each row. These tiny holes are spaced according to the planting distance of the crop; rather, the pipe used is choosen according to the planting distance of the crop.

The drip system is most famous for its efficient use of water. The small amount of water used and the way it is applied - (rate of application), is based on the crops water requirement. The system is used to apply very close to the water uptake of the crop. The water used is usually about 50% of that used in a efficient sprinkler irrigation. In this type of irrigation, most of the space between the rows remain dry, unlike the flood system. It also differs from sprinkler irrigation in that it does not wet the foliage of the crop and the water is not blown away by the wind.

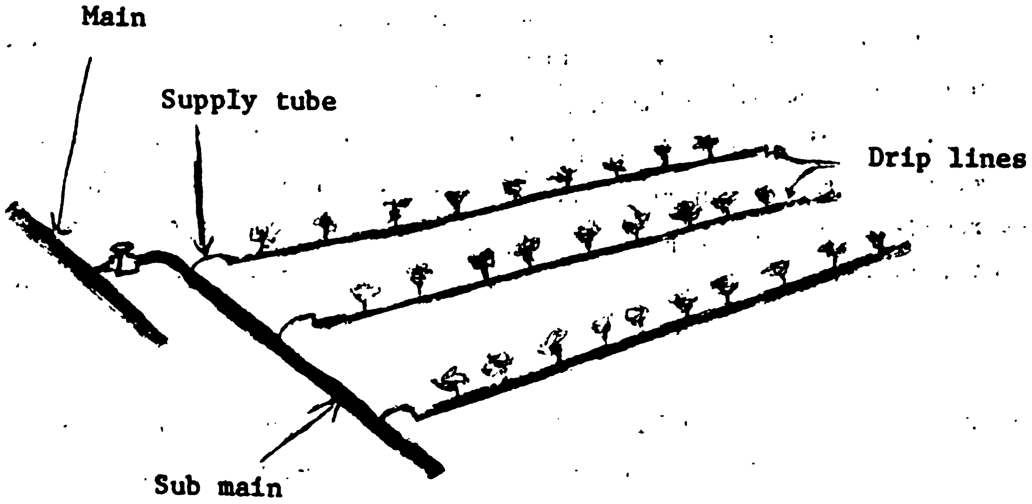
Yields from drip irrigation is usually 1/3 to 1/2 higher than other types of irrigation although the cost is almost the same as the sprinkler system. The drip system encourages the root to stay in the moist zone and easily soluble fertilizers can be applied through the drip lines.

What does a complete drip irrigation system include?

Storage tanks or sumps, a low pressure pump, main, filter, submain, drip line, and of course, necessary fittings and valves to connect them. The pump may not be necessary depending on the slope of the land.

The drip system uses flexible plastic or rigid plastic pipes with the size of the mains and lateral drip lines according to the amount of water per minute required to wet the field.

Mains and sub-mains may be buried to prevent them being damaged by farm equipment. But the drip lines are always placed beside the plants with single rows or between 2 rows on a bed.


Main
Supply tube
Drip lines
Sub main

If the land is sloping, the drip lines have to be placed along the contours to have a slow flow not more than the crop water requirement.

Where drip is used to supplement mulching, the drip lines can serve for a number of years depending on how much care is taken of them. Where the farmer has a limited amount of pipes, the pipes have to be shifted to wet the field in blocks. This practice however, increase damage and reduce the life of the drip lines.

Problems with drip.

1. The initial cost to buy pipes etc. is as much as sprinkler and more than flood or other surface methods

2. The problem with the drip system is that pores become easily blocked, especially where the water contain limestone, fertilizers or any particles not properly dissolved.

3. Rats and other small animals sometimes eat the drip lines causing leaks in the system

Advantages of drip

1. Applying fertilizer with drip irrigation

   When using drip, growers usually apply phosphate before or at planting and apply the nitrogen potash and more soluble fertilizers through the drip lines.

   Slow release or complete fertilizers can be placed in a band between the drip line and the plants. After applying fertilizers, it is good to wash out the lines by applying clear water for a few hours.

2. With drip, a farmer can spray, dust, pick and do inter-row cultivation while the field is being irrigated. Further, the need to control weeds is usually less since there is less weed growth between rows. Spraying may be more effective since sprays are not washed off the foliage. Disease and pests are not spread by the irrigation water.

3. There is almost no soil erosion due to irrigation
4. Drip uses less water.
5. Increase in yields.

Sub-surface Irrigation

In this method of irrigation, large pipe-lines are laid at a certain depth throughout the field. When water is applied in the lines, it soaks into the soil from the lower layers upward. It is difficult to use as the method requires:

1. A large supply of water.
2. A sandy loam top-soil through which water will pass easily to the surface and at the same time, a sub-soil that will not allow the water to sink easily.
3. Large amount of money for buying and laying the pipes.

Over-head Irrigation

In over-head irrigation, the water is carried from a canal, stream or pond to the field through a system of pipes. The water is pumped through the pipe lines. It is then distributed through a number of sprinklers in the field. Sprinkler irrigation as it is sometimes called, is suited for most soil types, for greater slopes and only furrows for drainage are needed.

(13:10)

Top - small portable pump.
Below - large portable pump on wheels.

Rotating sprinkler attached to metal pipes. Different heights are suited for different crops.

Laying out overhead system. (rotating - sprinkler system)

1. In most cases, a portable pump with a gasoline or a deisel engine or electrical motor is put near the water supply. A pipe either of metal or rubber, is put into the supply and connected to the intake of the pump.

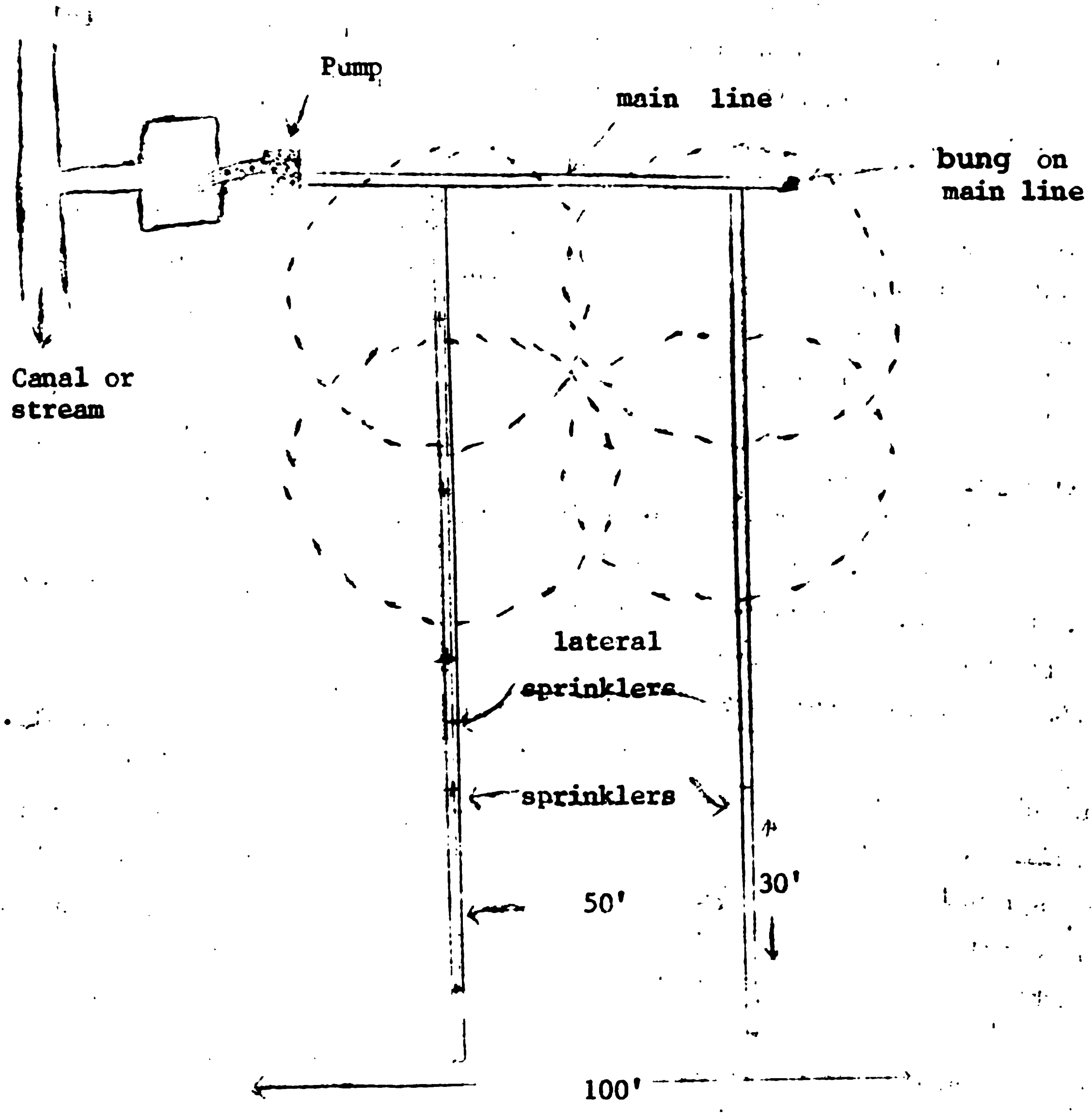
2. The main line with pipes of lengths of 20 - 30 ft (6 - 9m) and diameter 3-4 ins. (7-10 cm) are connected to take the water to the field. The end near to the water supply is connected to the out-let of the pump. The main line should run along the head-land of the field.

3. Smaller pipes of lengths 20-30 ft. with diameter of 2-3 ins. are connected to the main line. These are called laterals and are made of light metals or plastic. They are usually connected at right angles to the main line and run through the length of the field. Sometimes a sprinkler is attached to each lateral, while in other cases, some laterals are without. Despite this difference, they are connected to each other and to the main line so that the sprinklers can wet the desired area evenly. One or more lines of laterals can be used at a time depending mainly on the area to be wet and how powerful the engine is. During irrigation the sprinkler jets out water as it rotates and wets a circular area. The circle may vary anywhere from 20-80 ft. in diameter depending on the height of the sprinkler and how powerful the pump is.

4. After an area is wet, the main line and pump is shifted to another section of the field moving in one direction .

(13:11)

(Photo) Water being applied by rotating-sprinkler irrigation system.



(13:12) Diagram showing lay-out of rotating-sprinkler irrigation system. (The figures are for an example of a small unit with sprinkler ht. 18-24").

Another type of over-head irrigation - Turning pipe system. The turning pipe system (also called oscillating pipe system), is one that is less expensive than the rotating sprinkler system. It does almost as good a job as the sprinklers. Besides. there is no problem of one or two sprinklers jamming during an application or getting damaged from movement.

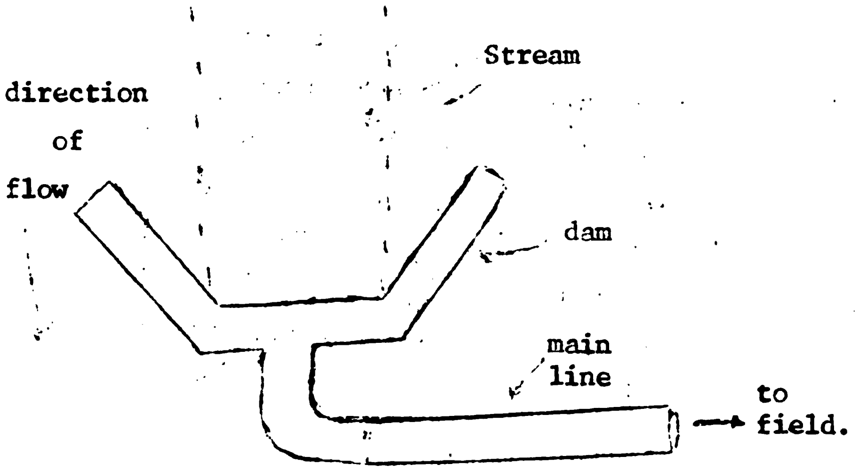
In this, a pump, main line and laterals are needed but these laterals are different from the rotary system. Some are plain pipes while others have a number of small holes (perforations) bored in a line on one side of the pipe. These are the ones that will be put in the area to be irrigated. When the system is connected and the pump turned on, water will jet from the holes and wet the area in the direction to which the holes are pointed. The holes would ~~point~~ at about 45 degrees to the surface. When one side is finished wetting, the perforated pipes are turned to wet the other side of the field without shifting the line. When that section is finished wetting, the line will be shifted.

(13:13) Turning pipe irrigation system in use.

There is also a system which is similar to the above type. In this, a hose is connected to a pipe or the main line supplying water. The hose has two lines of perforations so that there is no need to "turn" the pipes to wet any side of the line. Both sides of the line are wet together as in the rotating sprinkler system.

Over-head irrigation without a pump.

A field can be irrigated with sprinklers without a pump. This is possible where fast-flowing stream or canal passes near the farm. Here a small dam is made across the stream, but not high enough to completely block the flow. The water enters a main pipe which leades it to the field. One or two lines of laterals can be attached to the main line depending on the water pressure.



(13:14) Diag. - irrigation without a pump.

(13:15) Small dam and part of main line.

Such a method of irrigation is important to the small farmer who does not have the amount of money needed for purchasing and maintaining a pump.

Tanks and wells for irrigation

In some cases a farm is located where it can get water neither from stream, canals or ponds. Then a tank or a well has to be used instead. A well is usually so costly that it is almost impossible for small producers to drill one. Then such growers in a community have to unite with each other to do so.

However, sometimes a tank built on the farm will be of great help. Such a tank should be located where it can be easily reached from all sides of the farm. This could be used to supply water particularly for early growth of crops in periods of limited rainfall.

B. WATER REQUIREMENT OF CROPS.

The different vegetable crops absorb different amounts of water even when grown under the same conditions and where sufficient water is available to the crop throughout its life. This estimated amount of water required by the crop can be a useful guide to the vegetable grower as to how much water the different crops need for optimum production.

According to the amount of water available to the grower at different times of the year, he can use the water requirement of the crop as a guide as to which crop he can grow and give sufficient water. Generally, the deeper the crop grows and is capable of growing, the more water the crop requires.

For good yields.

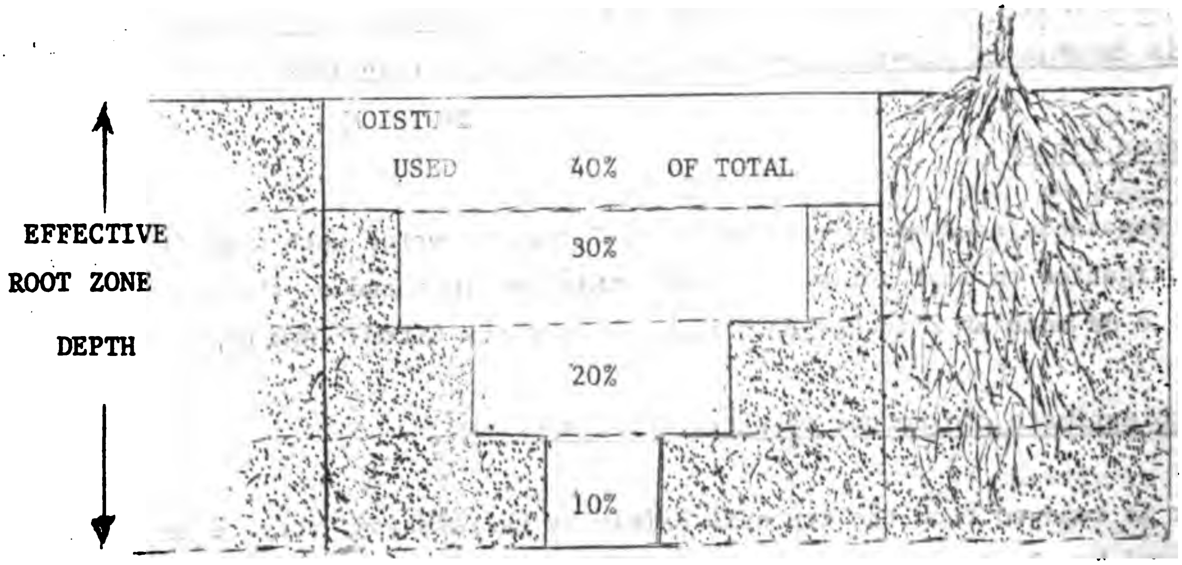
Most vegetable need an average of about 1 inch of water each week from rainfall or irrigation on most soils. However, this may increase as the soil gets more arid to as much as 2 inches each week on very dry (arcid soils.

How to estimate the amount of water to be applied.

Water is removed from the top soil mainly by evaporation, seepage into the subsoil and by plant use. The depth at which the plant takes water depends on how deep down the roots grow. But most plants absorb moisture roughly as shown below.

(13:16) Roots absorb most of its moisture from the top soil.

For example, a mature cabbage will send its roots to 1 1/2 - 2 ft. deep if it is not blocked by hard layers of soil. It means that of every 10 lbs of water it absorbs, 7 lbs will be taken from the top soil 9-12 ins of the land . It follows that the vegetable grower must make sure that this top 9-12 ins should have adequate supply of water. This is even more important when the crop is young. Then it depends only on this area, as its roots are not developed enough to take water from deeper down.


EFFECTIVE
ROOT ZONE
DEPTH
MOISTURE
USED 40% OF TOTAL
30%
20%
10%

Here is a guide to determine the amount of moisture that is available to the plant.

Table (13:17)

Available moisture left in soil.	Feel or appearance of soils of different textures		
	Sandy soils	Sandy loams	Clay loams & clay soils
0-25%	Dry, loose, flows through fingers	Dry loose flows through fingers	Hard, baked and cracked
25 -50%	Appears dry and will not form a ball when squeezed.	Appears to be dry and will not form a ball when squeezed	Will form a ball under pressure but this breaks up easily
50 -75%	Appears dry and will not form a ball when squeezed	Will form a ball when squeezed but this will not stay together.	Forms a ball that will not break up easily.
75 -100%	Will form a ball when squeezed, but this will not stay together.	Will form a ball more easily, but this will not stay together.	Forms a ball that will not break and will have a very sticky feeling.
100% (field capacity	When the soil is squeezed, it will form a ball. No free water appears on the soil, but outline of the balls is left in the hand. (Above 100% free water will appear).		

To check the amount of available water, the vegetable grower will need to dig a smaller hole in one or two areas of the field. Soil should be taken from a depth of about half of the root zone ofthe crop at that stage, for the sample. The available moisture at this depth should always be kept above 50% available moisture.When it is less than this, the field needs watering.

After the field is irrigated about 3 hours later the soil should again be tested at the same depth to find out if sufficient water has been added to make the top half of the root zone well moist. (i.e. field capacity). With experience, these become less and less essential.

The amount of water that the grower needs to apply will therefore depend on the depth to which his crop grows. Remember that this includes the depth to which root hairs also grow and absorb moisture (i.e. root zone). (There is an instrument called a **tensiometer**, which can be used to determine accurately, the amount of water in the soil. But this is expensive and only necessary for experimental work).

Here are the 3 key points:-

1. The field is to be irrigated when the top half of the depth of the root zone of the crop is less than approx. 50% moisture level.

2. When the field is irrigated, water should be applied to make this top half of the root zone near soaking wet.

3. It is better to make one good wetting than a number of small ones.

Table (13:18) Rooting depth of some vegetable crops when plants are fully grown

Shallow (Max. of approx 24 ins or 2/3m)		Medium depth . (Max. of approx 42 ins or app. 1 m)		Deep (Max of approx 48 ins (1 1/4 m) and over)
Brocolli	Garlic	Beans	Muskmellon	Artichoke
Brussels spout	Leek	Beet	Mustard	Beans (lima)
Cabbage	Lettuce	Carrot	Pea	Parsnip
Cauliflower	Onion	Chard	Pepper	Pumpkin
Celery	Parsley	Cucumber	Rutabaga	
Chinese cabbage	Potato	Egg plant	Squash	Potato
Corn	Radish		Turnip	Tomato
Endive	Spinach			Watermellon

The root of most crop grows to about 1/4 of it maximum depth in the first 1/3 of its crop life, 1/2 in the second 1/3 and about 1/4 in the list 1/3 of the plants life.

How regularly should water be applied

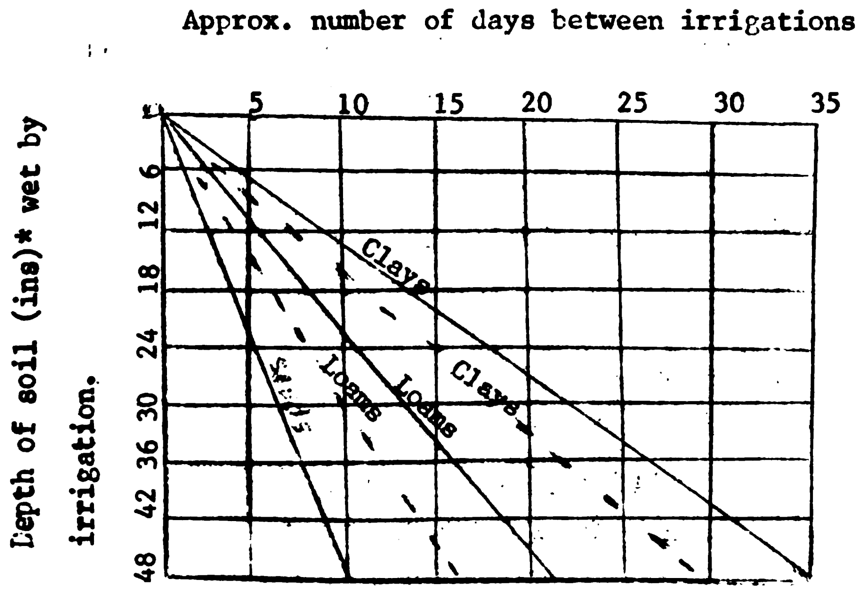
So far we have seen that water should be applied when the amount of available water in the top half of the root zone is approx. 50%. The number of days between one application and the other will depend on -

1. The soil type and how much water it holds in a single application i.e. the higher the moisture retention capacity of the soil, the less frequent will irrigation be needed eg. heavy soils would be irrigated less frequently than light soils.

2. Kind of weather since last application i.e. rate of evaporation and time and total amount of last rainfall.

3. The kind of crop and its stage of growth i.e. the deeper the root zone the less frequent irrigation needed eg. tomato would need less frequent irrigation than corn in the same area, although it would need more water overall. When the crop is younger, it would normally need more frequent irrigation than in later growth. Younger plants would need watering at least every other day, just to wet the depth of its root zone.
4. Amount of water applied each time.

(Fig. (13:19) This should be useful as a guide to the number of days between application.



Solid lines give reading for areas of low evaporation on clays and loam soils. Dotted lines give readings for areas of high evaporation.
Solid line give readings for areas of both low and high evaporation on sandy soils.

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* Multiply by 2.5 to convert to cm.

<u>How to use the table.</u>

1. Determine your soil type.

2. Find the maximum depth of the root zone of the crop at this stage (Table 13:18).

3. Find the amount of water in the top-half of the root zone (See Table 13:17).

4. Find this depth on the table. Rest a straight edge on the line representing the required depth.

5. Move a finger to the right across the page until the solid or dotted line is reached. The dotted lines would be for areas of high evaporation, while the solid line would be for areas of low evaporation.

6. Take the reading at the top of the table directly above this point.

<u>Example.</u>

If corn at 6 weeks old (root depth 24x 3/4 = 18") is being grown on a loam soil in an area or period of high evaporation, from the table it should be irrigated at approx. [illegible] days interval.

Note that rainfall during a period might increase the length of time between one application and another.

As the vegetable grower becomes more and more experienced, his need for using tables to determine when to irrigate and how much water to apply, becomes less and less needed. <u>Remember, always try to keep the amount of water in the root zone, especially the top-half, well above 50% moisture level.</u> (See Table 13:17). Avoid making soil soaking wet or above field capacity for more than a few hours.

How much water and for how long should water be applied?

The texture of the soil affects the rate at which water will infiltrate the soil - i.e. the infiltration rate.

- Sandy soils have a high infiltration rate (> 1.5 ins per hr.)
- Loam soils have a medium infiltration rate(0.5 -1.5 ins per hr)
- Clay soils have a low infiltration rate ($\underline{/}$ 0.5 ins per hr)

The rate at which water should be applied to the field depend on how permeable the soil is. To avoid plenty evaporation or water loss from drainage, water can be applied more rapidly to sandy soils than to clay soils. And despite the texture, water should be applied slower as the slope of the land increases. But the length of time that water is applied for, depends mainly on the amount of water to be applied, and the rate at which this water is applied.

Learn this -

A flow of 500 gallons (approx 2000 l) per minute (app. 1 c.ft per second), will take about 1 hour to wet an acre of dry soil to a depth of 1 inch OR 500 galls per minute supply 1 acre - inch in 1 hour. .(1 acre inch app. 30,000 galls or 2.5 cm of water over 0.4 hectare = 114000 litre). The vegetable grower can use this to give him some idea of how long he needs to apply water to increase the moisture in the soil from one level to another.

Example: A farmer wants to wet a field which is 1/2 acre in size, to a depth of 6" using an irrigation system which supplies 400 gallons per minute, to raise the available moisture from 50%.

If 500 galls per minute wet 1 acre-inch dry soil in 1 hour
500 galls per " " 1/2 acre to 6 inch " " " 1/2x6=3 hour
400 galls per " " 1/2 acre to 6 inch " " " 3x5/4=3 3/4 hr.
But the soil is about 50% moisture.

To properly wet the field (raise moisture to field capacity) he would need to apply water for about 2 hours. Where evaporation is high, the farmer might run his irrigation system for another half-hour. But under tropical conditions most vegetables need about 1-2 inches of water each week from rain and, or, irrigation to grow well. The crop soil type and climate of the area are the main factors which will affect the amount of irrigation needed.

C. DRAINAGE

Importance of drainage

The purpose of drainage is to remove excess water from the field. This water, if allowed to stay in the field would have adverse effects on the crop. Drains are cut in the field to remove this water and speed up the internal drainage of a soil. This point should be mentioned here again - i.e. While vegetable crops need adequate supply of water for maximum growth and production, this water must be able to move fairly easily out of the soil.

This sentence is a key one, as the easy movement of sufficient water in and out of the soil is so important. When a farmer asks how he can increase production on his farm the first advice that should come to mind is -
" increase water supply and improve drainage" (This advice could not be immediately given to the farmer as his problems should first be checked and the relevant advice then given).

When is drainage most needed?

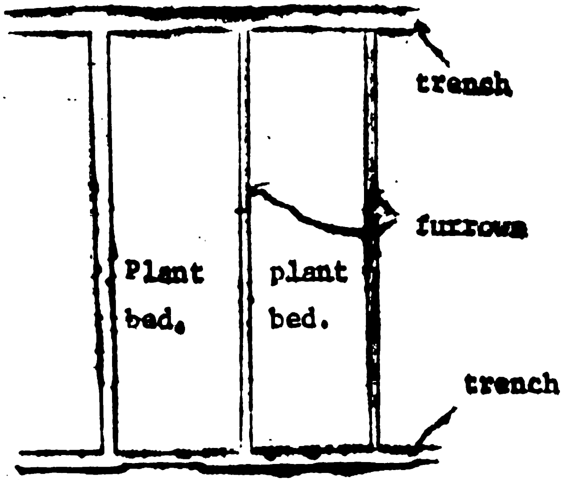
Drainage is most necessary when crops are grown under the following conditions-

1. In periods of regular moderate - heavy rainfall
2. In periods of low rate of evaporation.
3. On land that is relatively flat.
4. On heavy soils i.e. some loams and clays.

Furrows, trenches and drains

Remember we said that drains are used in drainage. (This sounds like a great discovery). But "drains", is only a new word for two words we have been using so often viz furrows and trenches. Let us say that the furrows are small drains used in the field between the rows of the crops. Then trenches would refer to the large drains used to remove water from the entire field.

So that furrows and trenches (or ditches) can be used to add irrigation water, but they can also be used to subtract water in drainage. In some cases the internal drainage of the soil is rapid and the grower needed to reduce water loss. One of the first things he usually does is block his furrows where they enter the trenches, and then block the trenches. OR, if it will not be necessary later, in his land preparation, he keeps the number of drains to a minimum.



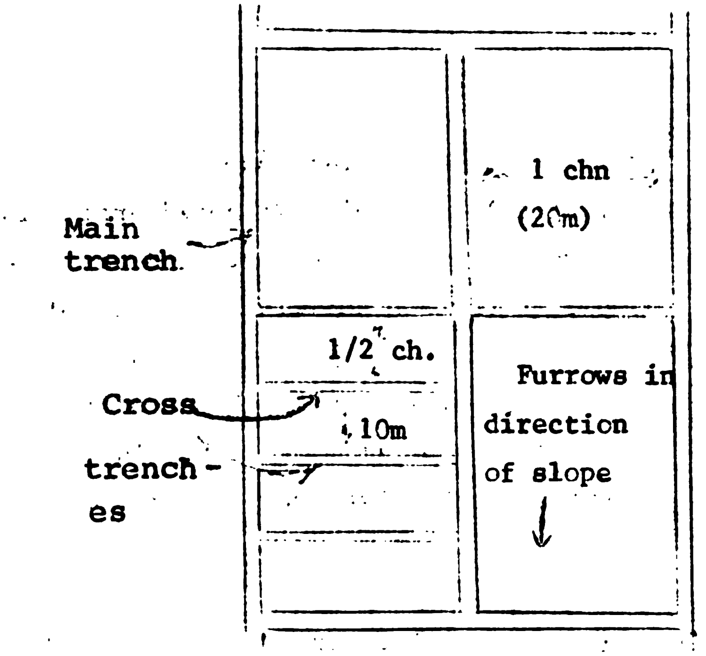
(13:20) Types of drains.

How to apply drainage.

It is difficult to illustrate as the type of drainage needed will vary so much from place to place. There are one or 2 general points ie.-

1. Furrows should be further apart on light soils as these would have rapid internal drainage (5-10 ft. or 1 1/2 - 3 m)and they should be nearer to each other on heavier soils. (2-5 ft. or 2/3 - 1 1/2 m)

But if drainage is needed for example during periods of frequent heavy rainfall, on heavy soils, here is a guide.



(13:21) Plan of a drainage system

The field is ploughed and the furrows made in the direction of the slope. A system of main trenches (12 ins wide x 9 ins deep or 30x22 cm) and cross trencehs (9" wide x 6" deep or 22x15 cm) is cut through the field. Drainage can be controlled by blocking and opening the trenches as required. The distance between the cross trencehs can be adjusted to suit the existing conditions in the area. The flatter the land, the nearer these trenches should be, and the heavier the rains the same things holds. For opposite conditions, the cross trenches would be further apart.

Spot-drainage - Sometimes, there is a wet patch in one or more areas of the field. In this, the vegetable grower should use his judgement to cut one or more drains away from these wet spots to remove the water from the field or to distribute it to dryer parts of the field where it is needed.

Chapter 14. MULCHING AND INTER-TILLAGE

A. MULCHING

Importance of mulching

1. Mulching is a measure used mainly to reduce water loss due to evaporation from soil (i.e. conservation practice). In this the soil surface is covered preventing it from being directly exposed to sun, wind and other drying effects. The material used to cover the soil is the mulch. Mulching is most beneficial when the crops are to be grown in areas of high evaporation and limited rain or irrigation water. Under these conditions, mulching markely improves both total yields and fruit quality. In some cases, the mulch raises the soil temperature and this makes the crop mature a little earlier.

2. Mulching is also a very effective means of controlling weeds as the area right around the vegetable plant is covered. So that the mulch blocks the growth of weeds and cut down on the amount of sunlight needed for rapid growth of the weeds. This in most cases does not prevent the weeds from growing, but it reduces the amount and the rate at which they grow. By controlling weed mulching further reduce moisture loss by reducing the amount of water that the weeds would take from the soil.

3. Mulching can also help to reduce erosion on slightly sloping land.

Types of mulch and how to apply them

The most commonly used types of mulch are:-

(i) Plant material eg. grass, bagass, corn plant after reap.

(ii) Animal bedding i.e. mixture of animal faeces and plant material.

Note - Manures applied to soil surface acts as mulch. Also used but not as widely are:-

(iii) Papae (iv) Plastic (v) Sand and course gravel (vi) wood shaving.

Grass mulch

This is the plant material most widely used as mulch. It is applied as dry fresh material or as slightly decayed material in which case it is partly manure. But because in mulching a wide area has to be covered, using the dry material reduce the amount needed.

Guinea, seymore and para grass are all suited for mulching, with guinea grass being the best. It is usually most available, covers a relatively large area and takes longer to break down, so it can be used for growing more than one crop. Organic materials that are known to be from diseased sources or grass reaped with seeds or with roots which will grow easily should not be used.

(14:1) Escallion growing under grass mulch.

How to apply the grass.

Where water is available to start the crop.

1. Prepare the land and plant the crop (See land prep.). It is best to plant in furrows here. Grow the crop with the water available until it is well established i.e. either by planting to fit rainfall or using the irrigation water available (This is where a tank can be very helpful). Apply about 1/2 the recommended fertilizer.

2. When the crop is well established, before planting dust the field with a recommended insecticide. This will help to control insects particularly slugs that tends to accumulate under the mulch.

3. Spread the grass between the rows and between the plants if necessary. The mulch can be anywhere between 1-3 ins thick depending on the rate of water loss in the area and the type of mulch used. Occassional irrigation or rainfall can reduce the thickness required. The mulch should be applied as evenly as is practical. If the area is windy, it will be difficult to spread the mulch. The easiest way of beating this problem is to plant wind breaks which when they grow up, will make mulching much easier. An economic crop not necessarily a vegetable crop, can be

planted in such a way as to divide the field into sections. Sections of an acre are quite reasonable. Crops like oranges should not be used as wind-breaks as the wind will blow off the flowers and fruits. The crop must have a firm root system.

(14:2) Cassava used as wind breaks around a watermellon plot.

Where water is not sufficient to start the crop

1. Prepare the land in the way most suited for such seasonal conditions. Try to avoid more than a single harrowing and open furrows for planting the crop in them. This should be done a week or so before rain is expected.

2. Apply the recommended fertilizer to the field in a single application. Make sure that from 1/4 - 1/2 of this quantity is applied in the furrow.

3. Cover the entire field with grass except for the furrows which should be left clear. If very heavy rains are not expected, dust the field with an insecticide. Rest and watch the rain.

4. It is best to grow large seeded crops or those that can be grown by transplant. As is usually suggested, the crops for transplant should be set in nurseries and the land preparation done just before the seedlings are ready for transplant.

5. A day or so after a suitable shower of rain, the crop should be planted. This should be done when the soil is moist, but not soaking wet. Do not plant until the heavier rains are over as this can do considerable damage to the crop.

6. Water should be collected during the rains, which can be helpful to water the immediate area in which the seeds or seedlings are planted.

Generally, when using mulch, the basic practices might change slightly. For instance, when later fertilizer applications are to be made, these might have to be done when the rainfall will allow or if sufficient water is available then. It is best to use a number of small applications as this reduce the risk of over fertilizing. Pest control has to be more efficient and the field should be sprayed regularly. When weed control is needed, it is also more difficult. It is best to use herbicides here. The pre-emergence sprays are most suitable. Certain practices like staking are not necessary. The distance between the rows has to be increased to allow for movement in the field. When the crop is fully grown fruits will not rest on the ground. In some low growing leaf crops this eliminates the need to wash them before marketing. In Cucurbits mulching reduce disease attack on fruits especially fruit rots, and improves the overall quality of the fruits.

(14:3) Watermelion grown under grass mulch. The fruit does not rest on the ground.

Other plant materials as mulch.

Other plant materials such as the remains of a corn crop (stalk and leaves) bagrass and wood-shaving can be dried and used as mulch. Bagrass is the trash from cane after the sugar is extracted on an estate. The cane is not whole but broken up into bits and pieces. These are not as widely used as grass, but in areas where grass is hard to get, (as it is in nearly all areas), these should be tried.

Here are a few important points about bagrass and wood shaving.

1. These are not as difficult as grass and most other materials to transport and to spread in the field.

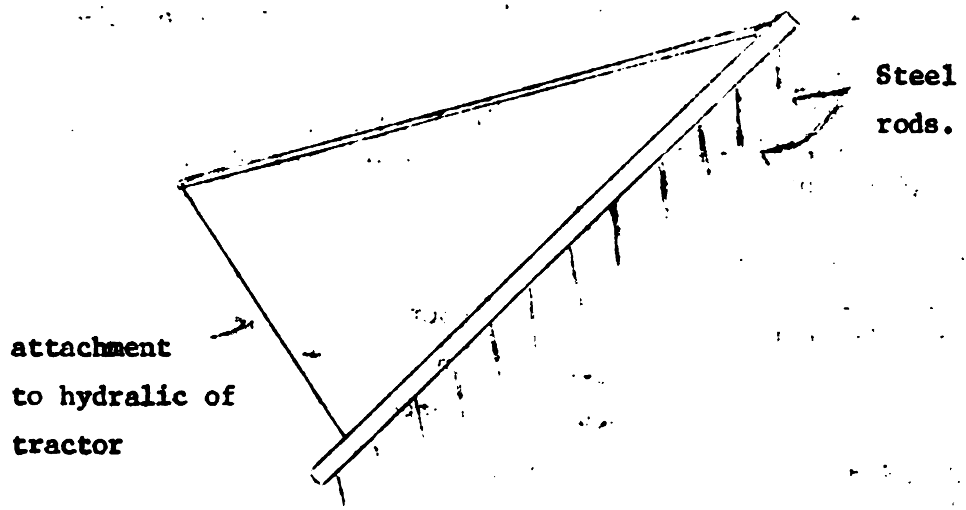
2. It is easier to make later fertilizer applications than when paper or plastic are used. Water can soak more easily through the bagrass and the shaving.

3. Insect control is not such a problem as with grass and other plant materials. The insects that live in the bagrass and the shaving seem to feed more on these materials and less on the crops.

Removing the plant material after harvesting

Because so much material has to be used in mulching, then the materials becomes hard to get and expensive. Sometimes in areas where mulching is widely practiced, the material is completely unavailable. Some vegetable growers can produce some of the mulch they use, but most of it he has to buy. (There are some farmers that produce grass for sale as mulch and for animal feed. These are grass farmers). So that the material is precious to the vegetable grower. After reaping, if possible, the grass should be removed from the field for a second planting. When . it is very hard to be removed, the mulch can be ploughed in where ploughing is required.

In small scale operation, a rake can be used to heap up the grass around the border of the field where it will be next used. But on large farms, the vegetable grower has to devise means of using the tractor to remove the mulch. A workable devise is to weld bits of 1/2 in steel (up to 24" long), to a metal bar and mount it on a cross bar attached to the hydralic of the tractor. The bar can vary from 5-10 ft. across, the steel rods should be blunt and put about 6-12" apart.



(14•4) Much rake for removing plant material with tractor

The tractor with the rake, can be driven across the field and the rake raised and lowered as is needed. In removing the mulch the rods should not be allowed to dig down into the soil.

Consider ways of improving this device and putting it to work on your farm. Then have a try at it. All the best of luck.

Paper mulch

Paper mulch is usually laid strip by strip at the same time that the seeds or seedlings are set out into the field. The mulch is laid down between the rows and wire staples or bits of wood used to hold down the paper. These are put at the edge of the paper and at intervals across the paper. A narrow bank of earth might also be used by itself along the edge of the paper. This reduces the amount of staples or bits of wood needed.

Paper mulch has essentially the same effect as when grass is used. However, it is more effective than grass particularly for control of weeds.

Note the following points in using paper mulch:-

1. Using paper mulch requires a large supply of cheap paper.

2. The paper is difficult to lay down.

3. The recommended fertilizer usually has to be added in a single application at planting.

4. The higher the rate of evaporation, the thicker the paper which should be used.

(14:5) Paper mulch used in growing beans on an experimental plot.

Plastic mulch.

Plastic mulch is laid in basically the same way as paper. It is the most effective mulch so far used both for reducing water loss and for weed control. Colours ranging from green to black are the ones most tested.

On sunny days, the plastic gets hot, the parts directly exposed to the sun gets so hot that it will scorch any part of the plant it touches. It is this property that makes it control the weeds so well. But then we should bear in mind that weeds are plants that are growing where they are not wanted. Now the fact that they are plants and the plastic kills them, means then that, there is no reason why if the crop is allowed to touch the plastic for any length of time, they will not be killed.

1. The plastic should not be put close to the crop especially during early growth.

2. Trailing crops or any crop that tend to touch the ground in later growth cannot be grown with plastic mulch.

3. Fertilizers have to be added in a single application.

4. Both weed and insect control are very good as neither can survive under the plastic.

B. INTER-TILLAGE

Importance of inter- (row) tillage.

Inter-row tillage is loosening the soil between the rows of a crop using hand tool, harrow or rotavator. It is not a practice that has to be applied under all conditions as is the case with say, planting and weed control. However, when it is done it can be of help to the crop in a number of ways viz.

1. Increasing infiltration of water in the soil. By tilling the area between rows, the soil becomes more loose. This prevents surface runoff of water applied, and this water can now soak more easily into the soil. So In effect, the water is first trapped, then penetrates the loose soil. This helps the crop in absorbtion of nutrients if the ploughing is done immediately before or after fertiliser application.

2. Improving soil aeration

   Loosening the soil also allows air to enter and circulate more freely in the ploughed zone. The increased infiltration and improved aeration directly increases growth and production of a crop.

3. Weed control.

   Inter-row tillage is most noted for controlling weeds. It is a mechanical means of controlling weeds. During ploughing, the weeds are covered in the soil.

4. Mulching. The loose soils forms a layer on the surface which reduces water-loss by evaporation from the soil beneath this layer.

(14:6) Inter-ploughing with a small tractor.

Problems in inter-tillage.

1. By loosening the soil in ploughing, rain water and wind can more easily erode the soil especially where the land is sloping.

2. Ploughing, damages the root system of the crop. The nearer the cultivation is done to the plant, and the greater the depth of the ploughing, the greater will be the damage. Sensative crops like cucumber will wilt if ploughing is done nearer than about 6 ins. (15 cm) from the plant.

3. If weeds are seeding, inter-row cultivation may help to spread the seeds.

(14:7) Roots of beet at depth of approx. 3 ins. Ploughing below this depth will destroy these roots.

When to do inter-tillage

Normally, inter-row work should be done [illegible] when soil is slightly moist. This should be done before irrigating the crop. Working on wet soil, will be muddy and will encourage lumping and cracking of the soil.

When 2nd or 3rd fertilizer applications are to be made it is best to do it with inter-row work. If solid material is to be applied then it should be spread between the rows and cultivation done immediately after. This makes the fertilizer more readily available to the crop. If the fertiliser is to be applied in irrigation water, tillage should be done before the application.

(14:8) Inter-tillage immediately after fertilizer application.

For effective weed control, herbicides can either be applied to the entire field and then ploughing done. OR, to reduce the amount and cost of using the herbicide, a selective spray can used between the plants and then inter-tillage done.

Type of equipments to be used

Both small and large tractors have special attachments for doing inter-row work. Most small tractors have the rotary blades (rotavator), which is used for all ploughing both before and after planting the crop.

This equipment is not the best especially for use on clay soils. It might have been used at planting, and with 2 or 3 inter-tillages, if the soil is not rich in organic matter, it might become powder after a year or two of cultivation.

How to do inter-tillage.

Inter-row tillage should be done by moving between the rows 6 ins from the plants on either side. Depth of plough should be shallow, ranging from 2-4 ins deep. Equipment should be adjustad to cut at the required depth. Depending on size of plant, variety slope of growth, the farmer may decide how near and how deep he should plough. For crops of short duration should be done or twice. For longer crops it can be done 2 to 3 times especially if the soil tend to crust or in cases of rapid weed growth.

Moulding (or Hilling)

Moulding is another type of inter row work. This is really a combination of 2 operations i.e. tillage between the rows and piling this soil around the roots in a single operation. This has all the beneficial effects of ploughing in addition encouraging the development of the root system of the crop. Crops like corn that grow fairly tall and tend to fall over from poor rooting get considerable help from moulding. Root vegetables sometimes, tend to grow upwards and expose a part of their tubers above the surface. This part will usually become tough and woody or might develop a number of cracks. In periods of heavy rain, water will soak into the tuber and cause it to rot. More often, bacteria and fungi invade the cracks and cause the diseases.Moulding is also helpful to these crops.

(14:9) Small tractor with special equipment for hilling

Chapter 15 . PEST, DISEASE AND WEED CONTROL

A. PEST AND DISEASE CONTROL

Pest and diseases that attack vegetable crops have been the greatest enemies of vegetable growers for centuries. Today, the relation is more or less the same except that the grower is better able to fight the enemies. The chief pests that will be dealt with are the ones that usually dothe most damage to crops. viz

(i) insects (ii) nematodes (iii) other pests - snail and rats

(15:1) Here is a list of some diseases and pests attacking a wide range of crops and some of the crops and parts they attack.

PESTS & Diseases	SOME CROPS ATTACKED	PLANT PART ATTACKED
Diseases		
AnthraCnose (fungus	Beans, Cucumber family, garden-egg, pepper	Fruit
Black leg (fungus)	Cabbage family, tomato.	Lower part of stem.
Black rot (fungus)	Cabbage family, potato.	
Bacterial blight (bacteria)	Corn, garden egg, okra	
Blight (fungus & bacteria)	Beans, carrot, potato, spinach, tomato	Foliage and fruit
Damping-off (fungus)	Nearly all vegetable crop at seedlings	Whole plant
Fruit rot	Nearly all crop under excess moisture at fruiting	Fruit
Fusarum wilt (fungus)	Cabbage family, celery, peas, tomato	
Leaf spot (fungus)	Beet, , chard, pepper	Leaf
Mildew (fungus)	Most vegetable crops .	Foliage and fruit .
Mosiac (virus)	Bean, celery, endive, lettuce, pepper, tomato	Foliage and fruit
Root rot (fungus)	Nearly all vegetable crops under poor drainage.	Root .
Rust (fungus)	Bean, corn..	Leaves

PESTS & Diseases	SOME CROPS REGULARLY ATTACKED	PART ATTACKED (contd.)
Scab (fungus	Cucumber family, potato, radish	
Smut (fungus)	Corn Onion	
INSECTS		
Aphid (suck)	Nearly all vegetable crops	Foliage
Armyworm (bite)	Cabbage family, cassava, corn	Foliage
Beetle (bite)	Beans, beet, cucumber family, garden-egg	Whole plant
Cornear-worm (bite)	Beans, cabbage family, corn cucumber family	Foliage
Cut worm (bite)))	Nearly all vegetable crops/particularly at seedling stage .	Leaf and stem
Crickets (bite)		
Diamond-back moth larva (bite)	Cabbage family	Foliage
Hornworm (bite)	Tomato	Foliage
Leaf-miners	Nearly all vegetable crops	Leaf
Mites (suck)	Beans, celery	
Stink-bug (suck)	Okra, tomato	
Thrisp (suck)	Onion	
White fly (suck)		
Weevil (internal)	Bean, carrot pepper potato	Stem and root
Wire-worm (feeders)	" " " "	
NEMATODES	Tomato to family and others	Mainly roots
Other Pests		
Slugs and snails	Most vegetable crops	Foliage
Rats	Attack most mature crops in field and when stored.	Part of plant feaped.

Importance of pest and disease control.

Controlling pests and diseases is important to the vegetable grower for a number of reasons, mainly:-

1. By controlling them, the amount of damage done to the whole plant or a part of it is reduced. For example, when the insect damage leaves, it directly reduces the rate of food manufacture while nematode damages to roots reduces absorbtion of nutrients. The net result is reduction in production of the plant.

2. Pests and diseases attack mature fruits making them totally unfit for market. Within a few days, a crop that was growing well might be destroyed. A severe attack of late blight on tomato a few days before reaping might make a whole field unfit for market. If the grower is not careful, it might also affect later crops (See after-reap work).

3. Control of insect pests reduce the rate at which diseases are spread. Aphid is an insect that attack vegetable plant parts but is most damaging because it also spreads a large number of diseases. The same is true of the Stink-bug which also spreads mosaic virus diseases.

Vegetable diseases (bacterial) transmitted by insects.

Disease	Insect	Host	Means of spreading
Black-leg	Cabbage maggo	Cabbage	Spores carried into plant.
Cucurbit wilt.	Cucumber beet	Cucumber	Enters in insects feaces on plant wound
Bacterial soft rot	Fly maggots	Potato, Cabbage, Tomato and some other veg.	Spread by eggs of flies layed on fruit.
Potato scab	Potato flee beetle	Potato	Larva enters tuber carrying disease
Fusarium wilt	Grasshopper		
Downey mildew	Bees	Lima Beans	Transmitted to flower.

Vegetable diseases (virus) transmitted by insects.

Leaf roll	Aphid	Potato	Innoculation by feeding
Bean mosiac	"	Bean	" " "
Crucifer mosiac	"	Cabbage mustard and turnip	
Sugar cane mosiac		Corn	" " "
Cucumber mosiac	Mellon aphid & cucumber beetle	Cucurbit	" " "
Beet mosiac	Aphid	Beet	" " "
Yellow dwarf	"	Onion	" " "
Spotted wilt	Thrips	Tomato	Nymph "must feed on disease plants.
Aster Yellows	Leaf-hoppers	Many vegetable crops.	Innoculation in feeding.
Curley top	Beet leaf hopper	Many vegetables	" " "

METHODS OF CONTROLLING DISEASES, INSECTS AND NEMATODES

There are 4 main ways of controlling them.

1. Planting varieties and crops which are resistant

2. Improving practic es in growing crops

3. Using biological agents.

4. Using pesticides and fungicides.

These methods are to be seen as supplement to each other. eg. while pesticides are used, then improved practices, resistant crops and varieties should all help to make control more effective.

1. Planting resistant varieties -

Certain varieties of most crops are more resistant to some pests than others. But resistance is often inadequate and as much needs to be supplemented with other forms of control. Example- Manapal tomato is more resistance to fusarium wilt than most other varieties and Nemagreen beans are more resistant to nematode attack.

Resistant crops: - In certain areas it is very difficult and expensive to control some pests on a crop. Sometimes this is so for the entire year, but more often control is difficult only for a certain period. In such a case it is best to plant a different crop during the difficult period. This crop should be one that will not be attacked by the particular pest.

Example - The Diamond back moth will literally kill all members of the cabbage family at certain times of the year. But, it does little damage to lettuce or chard. It might be a good idea for the vegetable grower to plant lettuce instead of cabbage at this time. Similarly, nematodes can cause a loss to the grower if beans or tomato are planted in infested fields. But it is relatively harmless to corn

(15:3) Damage by diamond back moth.

2. Improve practices in growing crop.

Almost all practices in vegetable production can be improved as a means of pest and insect control. Planting time, fertilizer application, weed control, drainage, correct use of chemicals and crop rotation are all practices that can directly help control.

Example - By planting a crop at a certain time, the vegetable grower can avoid having to reap his crop in periods of very heavy rainfall. During this period the crops particularly fruits are more suspectable to disease and insect attack. In addition, control is more difficult as the sprays that could be used are easily washed off the plant.

Improved weed control can also be a means of controlling pests. In some cases, although the crop is tastier to the insects and they prefer to feed on it, they can also feed on the weeds. If weeds are not controlled both in and near the field, these will act as a reservoir for pests. This is particularly true for weeds at the edge of the field and on the banks of canals. So that when the field is sprayed, the insects will survive on the weeds and their larva later attacks the crop damaging plant parts and spreading diseases.

Example - The tomato mosiac virus is rapidly spread in areas where some grasses (mainly guinea grass) is plentiful. This is because of the main vectors (i.e. carriers) of the disease is the stink bug which lives in the grass. Control of the disease can only be effective by cutting grass away from the edge of the tomato field and then spraying the grass at a given interval with chemicals that will kill the bug.

Crop Rotation

Planting vegetable in the same area for a number of successive crops is a bad practice. There are 2 main reasons why this is so.

1. The crop will utilize most of the soil nutrients from a certain level leaving a higher amount of nutrients at other levels of the soil The crop may also deplete one or more elements depending on its nutrient requirement.

2. Pests that attack that crop will tend to build up in the area and make it more difficult to control them in each later crop. Soil-borne pests become most serious but others will accumulate through their eggs and spores after the crop is reaped and ploughed in the soil.

To make better use of nutreints and reduce this build up of pests, a system of crop rotation should be used. <u>In this the location of crops on a farm are changed</u> in a definite pattern, usually after each crop.

Example.

Cabbage planted in a field for a number of successive crops, will absorb nutrients from the top 18-24 ins of the soil and cause a build up cutworms, loopers, miners, black-leg and other pestsof the cabbage family. Rotating this crop with been, would allow use of nutrients deeper in the soil (3-4 ft.), and few pests of cabbage would attack the legume. It would be difficult for most pests and diseases of cabbage to survive while the beans are grown in the area, and their rate of breeding would be reduced. This would help to make chemical control more effective.

<u>A suggested system of rotation</u>.

The system of rotation given below is intended to be a guide to the vegetable grower. Because of the wide range of crops it is very difficult to make a rotation plan that will include all vegetable crops and at the same time satisfy the aims of crop rotation. The crops are put in <u>rotation groups</u> from considering the pests that will attack each and the depth of their root zones, i.e. in Gps. I and III most crops have deep root zones and most of II and IV have shallow root zones.

(15:4)

Rotation groups.	Crops
Gp I	Cucumber family - (cucumber, muskmellon, squash, watermellon) Tomato family - (garden-egg, pepper, potato, tomato)
Gp. II	Beet, chard, carrot, celery, endive, lettuce, spinach.
Gp. III	Beans, peas, okra.
Gp. IV	Cabbage family -- (cabbage, cauliflower, chinese cabbage, collard, Kohl-rabi, radish, turnip.) corn, onion.

Suitable patterns of rotation are:-

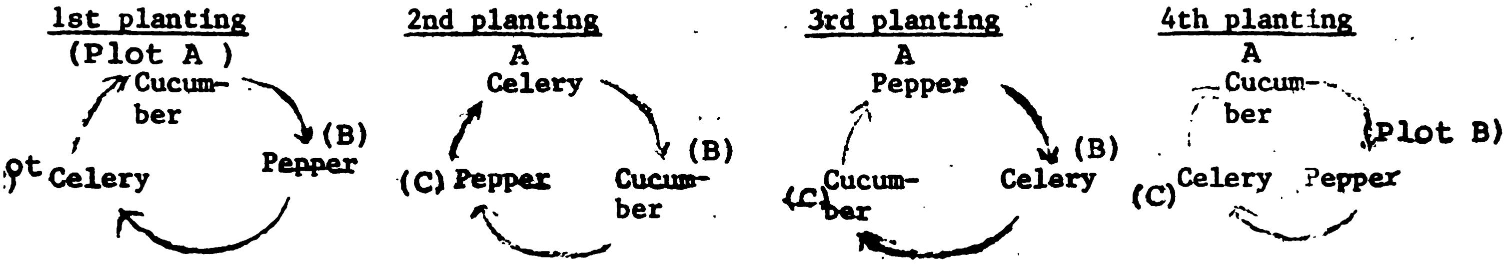
Gps. I ⇄ II i.e. Gp I to II and visa versa

II ⇄ III i.e. Gp II to III and visa versa

III ⇄ IV i.e. Gp III to IV and visa versa.

Example 1

A farmer producing cucumber, pepper (Gp.I) and celery (GpII) could rotate his crops as follows.-

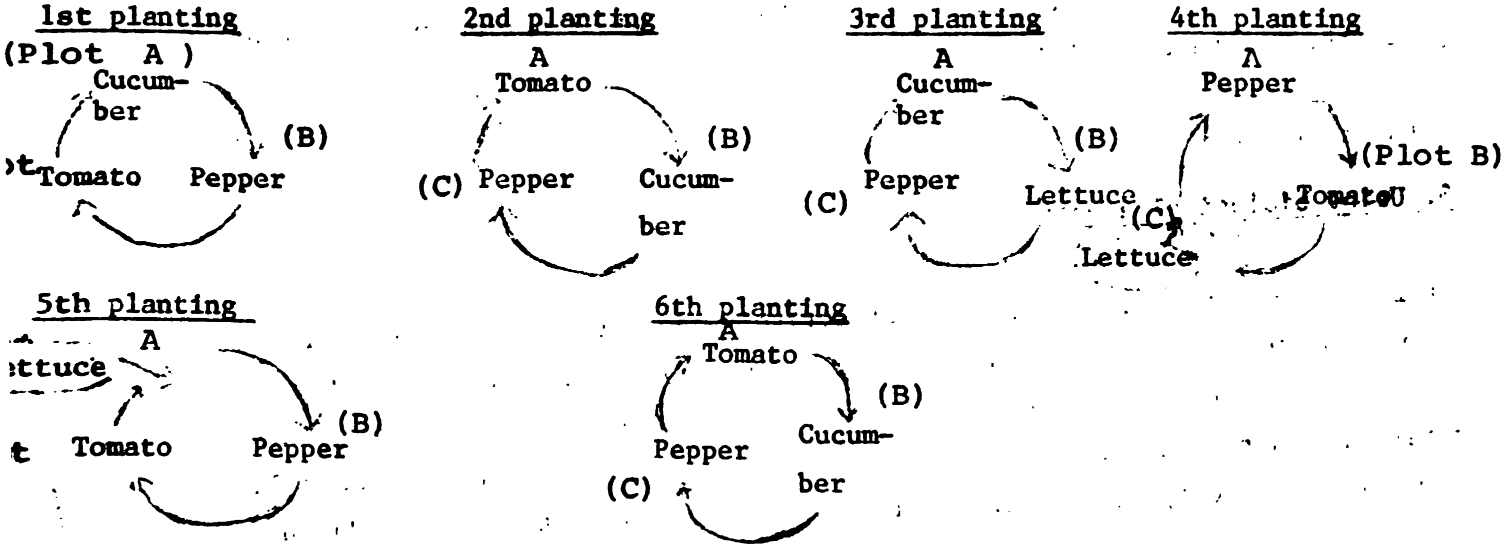


A smilar pattern could be used if he were growing crops from II and III (eg beet, beans, okra) or from III and IV (eg peas, corn, cabbage)

Note - The rotation pattern does not have to go in a orderly cycle in that direction. The pepper could very well be where cucumber was first planted. The important point is to avoid successive growing of crops at the same place.

Example 2

A farmer producing cucumber, pepper, tomato (Gp. I), could do this -



A similar pattern could be used if all 3 crops were from groups I and III or from II and IV. The vegetable grower particularly students should never give up his brain for any book and start using his head only for wearing hat. While he should use the system as a guide he should seek to develop one to suit his farm.

Introducing crops.

In Example 2 cucumber, pepper and tomato are the staple crops on the farm, but because all 3 are from the same group, at the 3rd planting lettuce is introduced. The practice of introducing a crop is to increase the efficiency of rotation and this crop should be from a group that will allow this. For example, it would not be of maximum benefit to introduce beans instead of lettuce here. Although the beans would be suited for helping in pest control, it would not help the grower to make better use of his soil nutrients. This is not to say that the vegetable grower should stick hard and fast to the suggested rotation pattern. But as much as it is practical and economically sensible, he should try to do this. Suppose, for instance, there is a good market for beans and poor market and other conditions would make it unprofitable to grow any group II crop, then it would be madness to introduce lettuce instead of beans. However, the grower should bear in mind that rotation is more for long-term rather than short-term benefits.

While a crop was introduced in example 2, in many cases, it would not be necessary to introduce a crop, as changing selling prices and seasonal conditions would make a farmer have to grow different crops at different times of the year. What a grower should do is to choose a crop that will satisfy both the market and his rotation pattern. We have seen earlier that this might not be the crop that gives the greatest short-term benefits.

Methods of control

3. Using biological agents.

Biological agents can be used most effectively against insect pests. In this a praedaticus insects (i.e. feed on other insects) are used to attack the insect that is pestering the crops. The praedator should feed on the insect pest but not on the crops. When introduced into an area, the praedator breeds and can effectively control the pest. This method of control is usually used where the other methods fail to control the particular insect. Example - Red spider mites which attack cucumber,can be controlled by another specie of mites (Phytoseiulus persimiles) which feeds on the red m ites. The white fly which attack cucumber and tomatoes can be controlled by introducing another insect (Encarsia formosa) in the area. This predator attacks the larva of the white-fly, and so, reduces the damage done to crops.

In most countries and especially tropical countries, the use of biological control is very limited.

<u>There are two main problems</u> in using biological agents.

1. In most cases, the individual grower does not have the knowledge needs for introducing the predators. This operation usually has to be done by a government and the farmer might loose a lot before it is applied.

2. Most predators while they feed on harmful insects also feed on helpful ones Wasps and bees are among the insects usually caught in this position.

There are two species of wasp (Apanteles systolla and Thyraella collaris) which have been used effectively to help control Diamond Back moth in many Caribbean countries. The wasps lay their eggs inside the pupae(worm) of the Diamond Back Moth. When the egg of the wasp hatches, its larva feed inside the developing moth. Eventually the pupae of the moth is destroyed and the adult wasp emerges.

4. <u>Using chemical control</u>

Some chemicals are used in controlling pests and diseases. They are by far the most widely used and a very effective single means of control. These are made up of chemicals which reacts with substances inside the body of insects and other organisms resulting in their death.

<u>The 3 types of chemicals</u> used for disease, insect and nematode control are-

- fungicide i.e. chemicals used for controlling diseases caused by fungus eg. Dithane.
- insecticides i.e. chemicals used for controlling insect pests eg. Sevin.
- nematicides i.e. chemicals used for controlling nematodes eg. Nemagon.

B. FUNGICIDES AND DISEASE CONTROL

Fungicides control diseases caused by fungus, but are of little help in controlling those caused by bacteria and viruses. In some cases, a fungicide is best suitable for controlling one or two diseases eg. Karathane for control of powdery mildew. (It also acts as an insecticide controlling mites - i.e. a miticide). However, the more recently developed ones, can effectively control a number of fungal diseases on a wide range of crops.

Example - Polyram - combi (metiram) can control :-

early blight
late blight
leaf spot
anthracnose
downey mildew
leaf mold
rust
scab

(15:5) Here is a list of some commonly used fungicides and the diseases they control.

Fungicides	Common trade names.	Some diseases controlled.
captan	Captan, Orthocide	Damping-off, black rot
chloronil	Spergon	Damping-off, mildew
dichlone	Phygon	Bacterial spots
ferbam	Ferbam, Fermate	
maneb	Maneb, Dithane M-22	Blight, mildew
metiram	Polyram-Combi	Anthacnose, Blight, Mildew, scab
nabam	Nabam, Dithane D-14	Anthracnose, smut.
thiram	Thiram, Thylate	Damping-off
zineb	Zineb, Dethane Z-78	Blight, leaf-spot, mildew, fruit rot.
ziram	Ziram, Methasan	Anthracnose, blight
	Antracol	
	Bordeaux mixture	Most fungal diseases
	Cupravit	Most fungus diseases
	Dithane M- 45	Blight, fusarium wilt, mildew
	Karathane	Mildew
	Kocide	Blight, leaf-spot, mildew
	Lanacol	Most fungus diseases
	Perenox	Blight, black rot, leaf spot.

Diseases caused by bacteria and virus have to be controlled by improved practices in growing vegetables. Some bacterial diseases can be controlled by chemicals known as <u>antibiotics</u>. These are produced by certain living fungi, but are not widely used. Bacterial spots of pepper and blight on beans have been successfully controlled by antibiotics. Further work on these chemicals might in the near future make the vegetable grower better armed to fight the pests.

Until now no chemical has been developed for controlling viral diseases. So that a vegetable grower has to depend totally on improving his practices for control.

Viral disease can be spread by farm equipment and insects which feeds on infected plant and spreads it when it feeds on a healthy plant. In cases where it is possible to see where the disease has started, it is best to remove the plants showing the symptoms. Bean mosiac is the most common example of a viral disease that might be controlled if the infected plants are removed as soon as the symptoms appear. These plants should be burnt or buried.

Most effective for control of both bacteria and virus diseases are improved practices. Crop rotation, rigid insect and weed control seem to be of great help.

(15:6) Disease that are best controlled by improved practices

A word of warning

Some diseases, particularly bacterial and virus diseases cannot be wiped out after they have been observed in the field. This is because by the time, the grower observe the symptoms, the disease has already spread over most of the field. The vegetable grower should remember that the disease might or might not cause a total loss. This depends on how serious the attack is and the stage of growth of the crop. i.e. early growth, late growth, fruiting etc. Therefore the grower should not go ahead and start to clear his field once he has seen symptoms of the disease. He would do well to watch and see how serious the attack is and if he would be able to make sufficient money even to cover expenses. During this time, he should do what he can to prevent the disease from spreading. He should also take steps to prevent such diseases attacking later crops. Remember that crop rotation and planting resistant varieties can be of great help.

Application of fungicides

Fungicides can be applied as dust and as sprays. Spraying is more often done as it is an easier and cleaner operation than dusting. If applied with a spread-sticker, sprays will remain on the plant longer as it cannot be easily washed off. The vegetable grower should note that it is only the portion of the plant that the spray or the dust cover, will be protected from the disease. It is for this reason that it is so important for the fungicide to be applied to the entire foliage. There are some systemic fungicides being developed which are absorbed by the plant and controls diseases in the entire plant.

When to start application - will depend on the crop hence the diseases that are likely to attack it. We should bear in mind that different diseases attack crops at different stages of growth. Early blight and late blight.for example are so named because one attack the crop as seedlings while the latter will attack at flowering to fruiting. For these and most fungal diseases application to prevent the disease (i.e. preventative application) has to be done as these diseases can hardly be controlled once they are allowed to attack the crop. In some cases (eg. mildew), spraying can start at the first sign of attack on the crop. Regularity of application - will depend on the disease and how serious the attack is. For most diseases, spraying is done at 7-10 day intervals/i.e. every 7-10 days after the first application. Where the attack is more serious and rain falls regularly, fungicides might have to be applied every 4-5 days. It is best for the vegetable grower to decide to do his spraying on a set day of each week i.e. 8 day intervals. This makes it easier for him to remember when his crop needs spraying. During a period of regular rainfall this would have to be altered.

Example

The recommendation for the use of Dithane M - 45 is a suitable example of when to start and how regular to apply a fungicide for controlling some diseases.

Crop and diseases.	When to apply.
Beans -	
anthracnose, downey mildew, rust.	Start application at first sign of disease and after flowering for anthracnose. Apply at 7-10 day intervals.

Crops and diseases.	When to apply
carrots -	
late blight, leaf spot	Start application when plants are 6-9 ins high. Reap at 7 -10 day intervals.
Cabbage family -	
anthracnose, downey mildew.	Start application on seedling. Apply at 3-5 day intervals on seedlings and 7-10 days in field.
Celery -	
early blight, late blight	Begin application when seedlings emerge and about a week after setting plants in field. Apply at 3-5 days interval on seedlings and 7-10 days in field.
Cucumber family -	
anthracnose, downey mildew, gummy stem blight scab	Start application when plants begin to trail or at first sign of disease. Repeat at 7-10 days interval.
Garden-egg -	
anthracnose, blight	Begin application when plants are 6-9 ins high or when fruits begin to form. Apply at 7-10 days interval.
Endive and lettuce - downey mildew	Begin application at first sign of disease. Repeat at 7-10 days interval.
Onion family -	
downey mildew, purple blotch	Begin application at 4-6 leaf stage or at first sign of diseases. Apply at 7-10 days interval.
Pepper -	
anthracnose, blight, ripe rot	Start application as fruits begins to form. Repeat at 7-10 day intervals.

Potato -	
early blight, fusarium seed decay.	For blight, begin application when plants are 3-6 ins. (7-15 cm) high or at first sign of disease in the area. For fusarium decay, dip seed potatoes in dithane solution before planting. Apply at 7-10 days interval for blight control.
Tomato -	
anthracnose, early blight, late blight, leaf spot.	Begin application either after emergence or at first sign of disease. Apply at 7-10 days interval.

Ref: " Superior Fungicide Dithane M-45"by Rohm and Haas - July 1964

G. INSECTICIDES AND INSECT CONTROL.

Insecticides are of 3 main types and are grouped according to the way they function. In some cases a single chemical function in more than one way. The three groups are:-

1. Contact insecticides.
2. Stomach (or gut) insecticides.
3. Systemic insecticides.

Contact insecticides kill the insects when it is sprayed on them or when they come direct contact with sprayed plant parts or fumes from the spray. These chemicals might not be effective in controlling adults insects which can fly off before the person using the spray reaches nearby. Some insects have tough outside coats which reduce the effectiveness of these insecticides.

Stomach insecticides poison the insect when it eats a part of the plant on which the chemical is sprayed. It is used mainly to control biting (or chewing) insects, but cannot effectively control sucking insects. These insects suck the juice from inside the plant so that the poison which is on the surface of the foliage cannot seriously affect them.

Systemic insecticides are absorbed into the plant through the pores when it is sprayed on the crop. These chemicals are the most effective single method of control and can kill both chewing and sucking insects.

When the insect attacks any part of the plant it is killed as the chemical circulates through the entire plant. So that whether it eats, the leaf or merely suck food from the plant, the chemical is still effective. But these chemicals usually have a longer residual effect, and should definately not be used near harvesting.

Bacterial insecticide (eg. Thuricide)

This is a special insecticide that has been developed. The chemical is selective and contains bacterial spores that is poisonous to larvae of the insects. It is sprayed on the foliage, and when the pest eats the plant material, it becomes paralized. The pest drops from the plant and starves to death.

(15:7) Below is a list of commonly used insecticides and some pests they control

INSECTICIDE	COMMON TRADE NAMES	SOME INSECTS CONTROLLED
Contact		
aldrin	Aldrin, Aldrex Agrocide	Armyworm, beetle, grasshopper.
aramite	Aramite	Ants
carbophenothion	Trition, Garrathion	* *
chlorodecone	Kepone	
diazinon	Basudin	
difocol	Kelthane, Acacin	Mites
dieldrin	Deildrin,* Deildrex	Armyworm, beetle, cutworm
dinocap	Karathane, Arathane	Mites
endrin	Endrin, Endrex	Armyworms, aphid, wireworm
fenitrothion	Folithion, Sumithion	Mites
malathion	Malathion, Maladrex	Aphids, beetles, thrips, white flies
phosmet	Imidan, Prolate	
phoxim	Valexon	
Gut		
calcium arsenate	Calcium arsenate	
naled	Naled	
Contact-gut		
	Baygon, Kyparin	
benzene hexachloride	BHC, Linadane, Gammalin	
bromofos	Nexion	
carbye (or carbaryl)	Carbicide, Sevin	Stink-bug, worms
chlordane	Chlordane *, Corodane	
endosulfan	Endosulfan, Thiodan	
fenthion	Baycid, Lebaycid	

heptachlor	Heptachlor, Drinox H-34**	
methiocarb	Mesural	
methomyl	Lannate	
mevinphos	Phosdrin, Phosphense	
mirex	Mirex	
TDE	Rhothane	Beetles, thrips, worms
toxaphene	Toxaphene, Alltox	Thrips
trichlorphon	Dipterex, Dylon	Worms, beetles.
<u>Systemic</u>		
demeton	Systox	
dicrotophos	Bidrin, Ektafos	
disulfoton	Di-syston, Dithio-systox	
fenchlorphos	Nankor, Trolene	
monocrolo-phos	Azodin, Nuvacron	Systemic insecticides can be used to control most insects attacking vegetables.
omethoate	Folimat	
oxy-demethonmethyne	Metasystox	
phosphamidon	Bimecron	
schradan	Pestox 3, systam	
	Perfecthion	
	Rogor	
<u>Bacterial insecticide</u>	Thuricide	All worms

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* Chlordone and Dieldrin are banned in some countries.

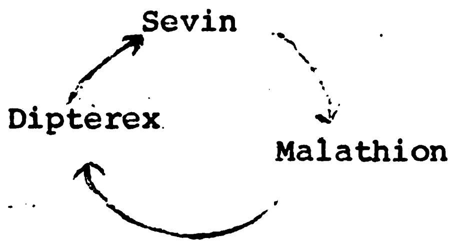
** Check manufacturers recommendations for pest controlled and other information not given.

Resistance to pesticides

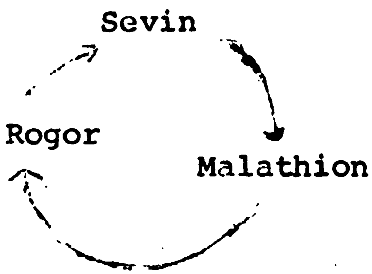
Pesticides generally are effective in controlling the pests that attack a crop. However, after using the same pesticide for a long time to control the same pest, its effectiveness is reduced. This is because each generation of insects have developed more and more resistance to the chemical. To maintain good control it is important for the vegetable grower to develop a system of chemical rotation i.e. when a pesticide starts to become ineffective, it is replaced by other suitable ones for a period before it is again used.

(15:8) Here are two chemical rotation patterns used successfully by vegetable farmers on biting insects.

1.



2.



Note -

1. For certain sucking insects the 2 patterns above could not be successfully used. Then the rotation pattern would have to include only systemic insecticides.

2. As more effective insecticides are available to the grower, these should be imtroduced to replace less effective ones in the rotation.

3. Rotating chemicals improves control of all kinds of pests. Farmers know from experience that when a rat bait is used for a time, it is very effective in killing these pests. But after a time, rats will start to feed on the bait.

Toxicity of pesticides.

Some chemicals are more toxic (poisonous) to man than others. The vegetable grower using a pesticide should know how toxic the material is i.e. its toxicity. This is very important for his own safety as careless use of all chemicals will be harmful to him, but with highly toxic materials, it might cost him his life. Usually the labels on the containers of chemicals will give information on how poisonous the material is. If moderate to highly toxic materials are used during reaping, the residual effect should be carefully checked.

Which chemical should I use?

Which type? - Before the vegetable grower can decide what chemical to use, he has to determine what type of pest or disease attacking his crop i.e. if it is an insect, he will need an insecticide, a nematode, a nematicide, a fungus disease, a fungicide. Remember that bacteria and virus diseases would have to be controlled by other means. With insects it is further necessary to determine what type of insecticide to use.

A few points should be mentioned here which will be helpful

1. Use of contact insecticides should be kept at a minimum as these generally are least effective. Except where the pest stays on the plants at all times, there is no gurantee that these pesticides can be very effective. When we come on to discussing weed control, we will see that contact weedicides give good control as the weeds cannot move away during application. However, with insect pests, especially those that can fly, contact insecticides are least effective for control.

2. Contact-gut insecticides give better results as it can kill insects on which it is sprayed and also those that eat the foliage. However, it can only control pests when they attack the sprayed portion of the plant. Because of this, it cannot control insects that attack the roots.

3. Systemic sprays generally are the most effective insecticides as they can control pests attacking any part of the plant. With contact and gut poisons the entire foliage has to be sprayed, with sytemic insecticides, this is not necessary. Applying the pesticide lightly even on the upper leaf surfaces would give adequate control. The result is that although systemic chemicals are usually the most expensive, because a smaller quantity will be needed for effective control, the vegetable grower might find it more helpful in the long run to use them.

Which pesticide? - After determing the type of pesticide to be used, the vegetable grower then has to decide which chemical he is going to ~~use~~. To do this he ~~must~~ first identify the specific pests that are attacking his crop. If it is fungus disease, he must know whether it is blight or mildew, if insect, he must know whether it is a worm or a bug. Knowing the name of the specific disease and insects is best, as he can more definately choose an effective chemical. Care should be taken to check the underside of the leaves as most pests will attack this part, but will not be observed until it has done considerable damage. ~~Checks should~~ be ~~made daily~~ for signs of pests. Biting insects will eat out ~~bits of leaves~~ and stems and can be readily identified. Sucking insects will not be as easily seen. Serious attack cause the plant part on which the insects are feeding to become twisted. The description of insects and signs of pests given under each crop in Sect.5 will be helpful here.

The vegetable grower knowing the type of pesticide he wants and the pest (s) he needs to control, should get well recommended chemicals to use on his crops.

It is important to use the correct pesticide recommended for the crop. Although Sevin for example can control a number of insects it should not be used on pigeon (gungo) peas as it will cause the plant to drop its leaves. This is the response of the crop to certain chemicals i.e. a phyto-toxic response. If the vegetable grower sticks to recommendations for pest control on each crop, he should not have much problem when he uses pesticides.

Spreader - stickers.

These are substances which when added to sprays helps the liquid to spread more and stick on to the foliage. It is usually available to the vegetable grower as a liquid and a recommended quantity should be added to the spray after it is mixed.

Stickers are not usually used with weed-killers but should be used with all fungicides and insecticides. This is particularly important during periods of frequent irrigations and rainfall when sprays will be easily washed off if a sticker is not added. The directions given on labels of containers will provide instructions on the amount of sticker solution to use and how to add it to the spray. Triton and Citowett are examples of spreader-stickers.

Residual effect of pesticides

Most chemicals used in pest, disease and weed control are harmful to man if certain quantities are taken into the body on food stuff or otherwise. Sometimes, the toxic effects of these chemicals last for a certain period after application. This is the residual effect of the chemical. During reaping, the vegetable grower should make sure that if he uses chemicals the residual effect has worn off before each reaping. At this stage, one can be fairly certain that the food will not harm the people eating it. The residual effect of pesticides and other chemicals is usually clearly stated on labels of the containers and is mentioned as a limitation in the use of the chemical. This period is from 3 days to 3 weeks for most chemicals. To play his game safe, a grower would do well to allow an extra 1-2 days more than given on the label before he does his reaping. This is an added precaution as we must always remember that these chemicals do not respect human life.

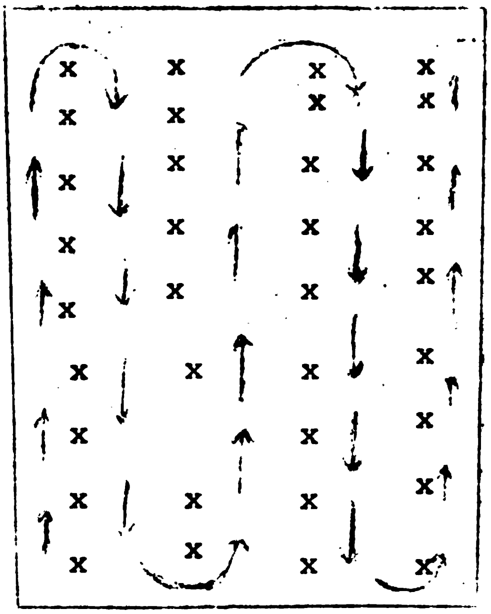
How to spray.

1. Apply spray lightly over the entire foliage.
   In applying pesticides, the vegetable grower should spray his field in such a way that the mixture is distributed over as much of the foliage as is possible. While his aim should be to cover all of the foliage. The spray is needed only as a light

film. It is a common practice to apply the spray so thick that after spraying, the spray drips like dew from the plants. Those crops will not be thankful as they get sufficient bathing during rainfall. Beside, the vegetable grower is wasting chemical and this will add to his total expenses.

2. In applying pesticides it is important that the spray is properly directed. The nozzle of the spraying equipment should be held in such a way that the spray reaches most of the foliage. For plants with their leaves arranged in whorls (eg corn, cabbage) it is important to apply the spray from both the underside of the foliage and from above. This allows control of pests in between the whorls of the plants. For plants with other leaf arrangements, apply the spray with the nozzle turned up beneath the foliage as the operator walks between the rows. Some spray would rise above the foliage and fall on the upper surface of leaves.

(15:9) Spraying with nozzle of sprayer turned up.



Start at left side of the field

x= plant.

(15:10) Diagram showing movement during application with a portable sprayer.

3. During application of the pesticide, the vegetable grower should move through the field in a way that will ensure that all rows are sprayed. This is so important as one or two rows left unsprayed can cause the pests to spread again more rapidly. This reduce the effectiveness of the application. The diagram to the left shows a suitable movement through the field during spraying. The arrows indicate how the person will move between the rows of the crop. If the operator starts at the right side of the field, he would move in the opposite direction.

D. MIXING AND APPLYING SPRAYS*

In mixing sprays it is important to know

- How much spray is required to spray the given area.
- How much chemical is required in the spray
- How to mix the spray.

How much spray is required

A number of factors will determine the amount of spray that needs to be mixed. However, the greatest one is whether low volume or high volume spraying will be done.

Low and high volume spraying

In low volume spraying (LV), a smaller amount of spray is used to spray a given area than in high volume spraying (HV). The same amount of chemical is used in both but a quicker method of application will be used in the field eg. with a spray boom attached to a tractor or with a mist-blower. These equipments apply the spray under very high pressure and the mixture is sprayed very thinly. With the tractor, apart from the thin spraying, the equipment moves over the field more rapidly.

In both cases, a lower volume of spray would be applied over the field. If a smaller quantity is applied, then it is necessary that the mixture be more concentrated to effectively control pests. (LV spraying is not recommended for post-emergent weed control as the slighest drifting of the spray will have damaging effects on crops).

Generally, about 4 times the amount of chemical is put in a given volume of water using LV compared to HV or LV sprays are mixed about 4 times as strong as HV sprays.

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* Note - This applies to sprays for pest diseases and weed control.

To determine how much spray is needed

Here is a simple method that can be used as a guide.

Steps 1. Mix the sprayer (knapsack or mistblower) full of the spray to be used. The amount of liquid the tank can hold (i.e. its capacity) would be marked somewhere on the sprayer or it could be measured. Follow the recommendations given on the container with the spray to determine how much concentrate is required and how to mix it.

Steps 2. Apply this spray to the field taking care to mark the sprayed area. A grower knowing the length of the field, can measure the width of the sprayed area and calculate the area sprayed. With experience, one can look at the area and make a fairly good estimate.

Steps 3. Calculate the approx. volume of spray needed for spraying the required area. Mix this amount of spray in one or two large containers at a time. A big drum (40-50 galls capacity or 150-200l) would be suitable. One can see that it is easier to mix the required quantity in one or two operations than several small ones. It saves so much more time. However, the amount of spray should be known to avoid mixing excess and having to waste chemical.

Here is a useful formula

$$\text{Volume of spray reqd.} = \frac{\text{Total area to be sprayed}}{\text{Area sprayed with 1 tank}} \times \text{volume of pan.}$$

Example

A 5 gallon pan of chemical was used to spray 2 sq. chn. of a field. The total area to be sprayed is approx. 1 ½ acre.

Volume of spray reqd. $= \left(\frac{15^*}{2} \times \frac{5}{1} \right)$ gallons

$= 37\frac{1}{2}$ galls.

Approx. Volume needed to spray the field would be 40 gallons.

How much chemical is required.

The quantity of chemical that should be used to mix the amount of spray required will depend largely on the form of the chemical.

Chemicals are usually sold in 2 forms viz

Wettable powder (WP) - in which the chemical is sold as dry powder containing different percentages of active ingredients.

Emulsifiable concentrate (EC) - in which the chemical is sold as a liquid containing different percentages of active ingredients.

The "active ingredients" is the"active part" of the concentrate. Remember when we were discussing fertilizers we said that a NPK/10-10-10 fertilizer contained 30% NPK. The remaining 70% was filler material. It is the 30% NPK that would be of use to the plant. We could say that it contains 30% active ingredients.

In mixing the spray -

1. The amount of the chemical to be used in a given quantity of water is calculated from the amount of active ingredient in the concentrate. This information is usually given on the lable of the container with the chemical.

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* Remember that 10 sq. chns. make one acre, 1 acre equal 0.4 hectare and 1 gallon approx. 3.8 litres.

Example

Deldrin is sold as powder containing 25 percent and 50 percent active ingredients (i.e. 25% WP nd 50% WP). It is also available as liquid concentrate containing 15% active ingredients (i.e. 15% EC)

For mixing a high volume spray -

Using 25% WP, mix approx. 12 ozs powder in 10 galls water (360 gm in 38 litres)

Using 50% WP, mix approx. 6 ozs powder in 10 galls water. (180 gm in 38 l)

Using 15% EC, mix approx. ½ pt liquid in 10 galls water.

So that if 40 galls (1501) of spray is to be used, it would require approx 24 ozs (3/4 kg) of 50% WP.Dieldrin.

2. In some cases (particularly weed-killers) the recommendation on the label gives the weight of WP or the volume of EC to be used per unit area. When this is the case, the vegetable grower should calculate the quantity of spray to be used on the area he wants to treat. This amount of chemical should be used in the required amount of water for mixing the spray.

Example

A recommendation for using deldrin (50%WP) on vegetable is at a rate of 2-3 lbs* per acre. A grower using 2 lbs per acre wants to spray 1½ acres, would need (2 x 1½)lbs i.e. 3 lbs of powder. This quantity would be mixed in 40 galls water. If the spray is to be mixed in a 20 gallon drum, then 1½ lb. powder would be mixed in each drum full of water.

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* Note - When the recommendation is given as a range, the more serious the problem is, the higher should be the quantity used within the given range eg. if the insect attack is slight, 2 lbs/acre or 2 kg/ha.dieldrin should be used, if serious more concentrate should be used but this must not exceed 3 lbs/acre.

How to mix the spray

For most sprays, the chemical is mixed in water. A few weed-killers need to be mixed in a thin oil such as deisel and kerosine oil. The directions for mixing the sprays is usually given on the label on the container. Generally for wettable powders, the required amount of powder is creamed with a small amount of water to form a kind of thick liquid mixture. This is done to enable proper easy mixing. For instance a 10 gallon drum of spray is to be mixed, the powder is put in the bottom with water, later added. It would require a special mixer to properly mix the spray as the chemical will either float to the top or tend to stick in the bottom of the drum. However, when the chemical is added as the creamy mixture it can be more easily and properly distributed in the spray. If a sticker is to be used, it should be added to the spray after the chemical is mixed.

Generally for liquid concentrates the required quantity of the chemical should also be mixed in a little water, then added to make the spray. Sticker- spreader can then be applied and the whole thing properly mixed.

Here are the generally recommended rates for applying some fungicides and pesticides

(15:11)

CHEMICALS	Amount per 10 galls* water-HV or 2½ galls LV.	Amp per one* gall water-HV	Residual effect of chemical
Fungicide			
Anthracol	3-3½ ozs* (app. 100gm)	1 tablespoon*	
Captan	4 ozs (" 120gm)	2 "	
Cupravit	4-5 ozs (120-150)	2 "	
Dithane M-45	3-3½ ozs (100gm)	1 "	3 days
Karathane	1-1½ ozs (40gm)	1 teaspoon	7-10 "
Kocide	3-3½ ozs (100gm)	1 teaspoon	
Maneb	3-3½ ozs (100gm)	1 "	
Perenoz	4 ozs (120gm)	2 "	
Polyram combi	3-3½ ozs (100gm)	1 "	
Zineb	3-3½ ozs (100gm)	1 "	7 days
		(cont'd..)	

* 1 gall = 3.8 litre, 1 pt app. ½l, 1 oz=30gm , 1 tablespoon = 15ml and 1 teaspoon = 5 ml.

Insecticide				
Aldrin				
Chlordane	(71-EC)	3/4 gill*	1 tablespoon	
Diazinon	(20-EC)	3/4 gill	1 "	10 days
Dieldrin	(50-WP)	6 ozs	2-3 "	21 "
Dipterex	(80-WP)	2-3 ozs	1 "	
Kilthane				7 "
Malathion	(57-EC)	½ - 3/4 gill	1 "	10 days
Perfecthion	(40-EC)	-	1-2 teaspoon	Use these before fruiting or head set for most vegetables
Rhothane				
Roger	(40-EC)	½ gill	2 teaspoon	
Sevin	(85-WP)	3-3½ ozs	2 tablespoon	
Trithion				

4 gills= 1 pint

Nematicide		
DD-Mixture		
Dowfume W-85)	Depend on concentration	
Nemagon (Fumazone)		
Slug bait		
Deldrin		Spread lightly
Mesural pellets		in infested area
Metaldehyde (sluggit)		2 tablespoon
Rat bait		
Rattex		Put a few blocks
Sorexa		in infested area.
Warfarin		

Note - In using all chemicals, it is best to follow the manufacurers instructions on mixing sprays, method of applicaiton, residual effects etc. despite advice from other sources.

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* 1 gill is approx. ¼ pint.

Applying fungicides and insecticides together

In pest control it is more economical for the vegetable grower to apply his pesticides together especially where the attack is not serious. Fungicides and insecticides are the chemicals that are most often applied together. Expenses for application are reduced as the vegetable grower goes through his field once instead of two times if each pesticide is applied separately. The quantity of each chemical in a given volume of water should be the same as the amount used when they are used separately.

Compatability of chemicals - Before chemicals can be applied together and give good results, they must be compatible i.e. each chemical must be able to work in the mixture yet at the same time, not affecting the other chemical (s).

Example - While malathion and captan can be mixed and give effective control, malathion could not be mixed with bordeaux and give good control. The chemical make-up of these two would cause them to react when mixed and produce a substance which would either be ineffective or toxic to the crop. So that not only must the vegetable grower be careful in the quantity of each chemical in the mixture, but must also make sure that they are compatible.

(15;12) The table below should be helpful here -

PESTICIDES	SHOULD NOT BE MIXED WITH -
(Insecticides)	
Aldrin	
Aramite	Bordeaux*
BHC	Bordeaux*
Chlor dane	
Cryolite	Malathion, nicotine sulphate, bordeaux*
Deildrin	-
Malathion	Cryolite, nicotine sulphate, bordeaux*
Nicotine Sulphate	Cryolite, malathion,

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* Bordeaux mixture of Copper Sulphate, burned lime and water.

PESTICIDES	SHOULD NOT BE MIXED WITH - (Contd.)
Potenone	Bordeaux*
Fungicides)	
Bordeaux	Look for asterisks (*)
Captan	Bordeaux*
Dichlone	Karathane
Karathane	Bordeaux*, dichlone
Maneb	Bordeaux
Zineb	Bordeaux*mercuric oxide
Ziram	Bordeaux*, mercuric oxide

Equipment for spraying

In spraying, 3 main sets of equipment are used viz -

1. Equipment for measuring chemical
2. Equipment for mixing the spray
3. Equipment for applying the spray

For measuring chemical - Before mixing, the chemical has to be measured. A measure calibrated in fluid ounces and pints would be best for using EC. However, a ½ pint measure can be used as a suitable substitute. Powders are usually sold in small packets ranging from ¼ lb to as much as 5 lbs. Where a small scale is not available smaller packets can be bought and the grower can develop a means of estimating the quantity he needs to measure out. (Metric measuring instruments are also available for these properties.)

For mixing spray - A vegetable grower should try to get hold of one or two 20 gallon drums for mixing his pesticides. He might also need the same number for chemical weed control. A stirrer will be needed to mix and agitate the spray from time to time. This can be made from a bit of board long enough to reach the bottom of the drum without the person using it having to put his hand in the spray.

For applying the spray - Sprayers of one kind or the other are most commonly used for applying sprays. These are made of material that will not be easily corroded by the different chemicals. Stainless steel, brass and plastic are most often used. Stainless steel is most resistant and these sprayers are usually the most expensive. Brass has the advantage of being easily welded and sordered. This is important as so often parts of sprayers get broken during its use. Plastic is light and cheap but least resistant to corrosion. Small sprayers should have a large opening so a hand can be pushed in the pan at least for cleaning the area around the mouth. A strainer should be fitted in the filler opening, one at a opening into the hose-line and another in the nozzle.

These should be removed from time to time and cleared of powder and grease and bits of trash that will block the hose and the nozzle.

Types of sprayers

For large scale operation what is known as a spray boom is attached to the tractor and pulled through the field. The spray is pumped by the hydraulic system of the tractor and the boom(tank) is usually of varying sizes.

(15:13) Tractor spraying with boom sprayer

For smaller scale operation, one or more of the following can be used-
(i) compressed air sprayer (ii) knapsack sprayer (iii) mist-blower.

Compressed air (or preumatic) sprayers are pumped up before use and during the spraying as the pressure goes down. During spraying, it can be carried on the back of the operator by means of shoulder straps.

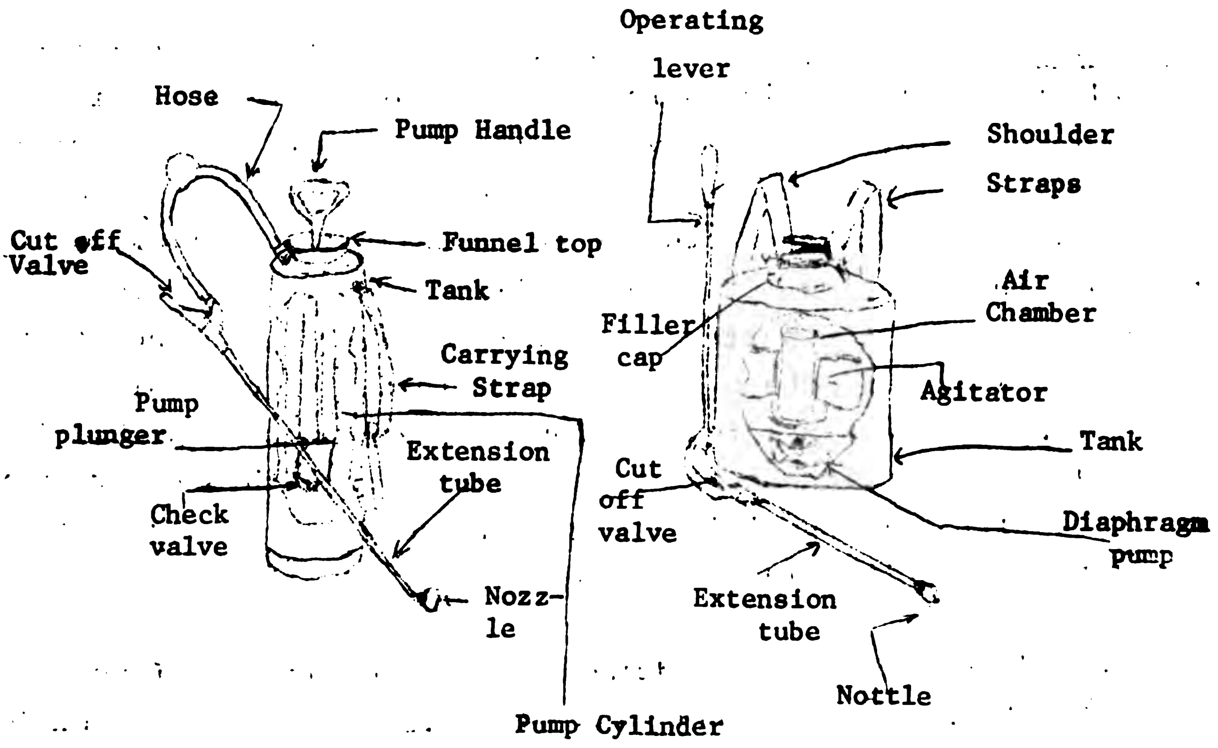
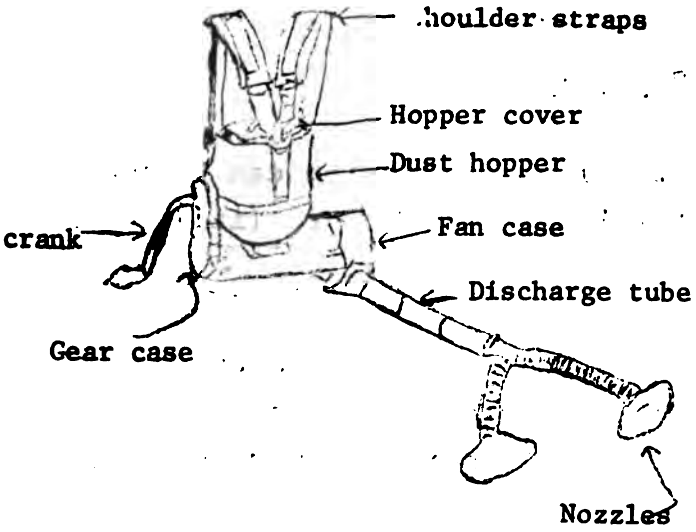

Hose
Pump Handle
Cut off Valve
Funnel top
Tank
Carrying Strap
Pump plunger
Check valve
Extension tube
Nozz-le
Pump Cylinder
Operating lever
Shoulder Straps
Filler cap
Air Chamber
Agitator
Tank
Cut off valve
Diaphragm pump
Extension tube
Nottle

Fig. 15:14


Shoulder straps
Hopper cover
Dust hopper
crank
Fan case
Discharge tube
Gear case
Nozzles

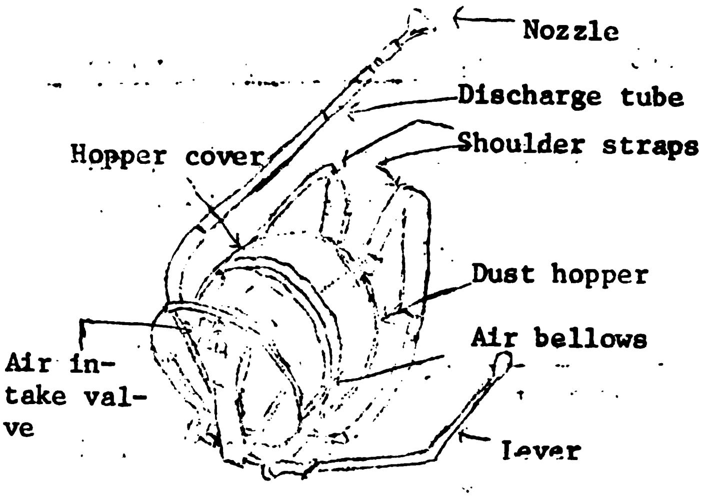
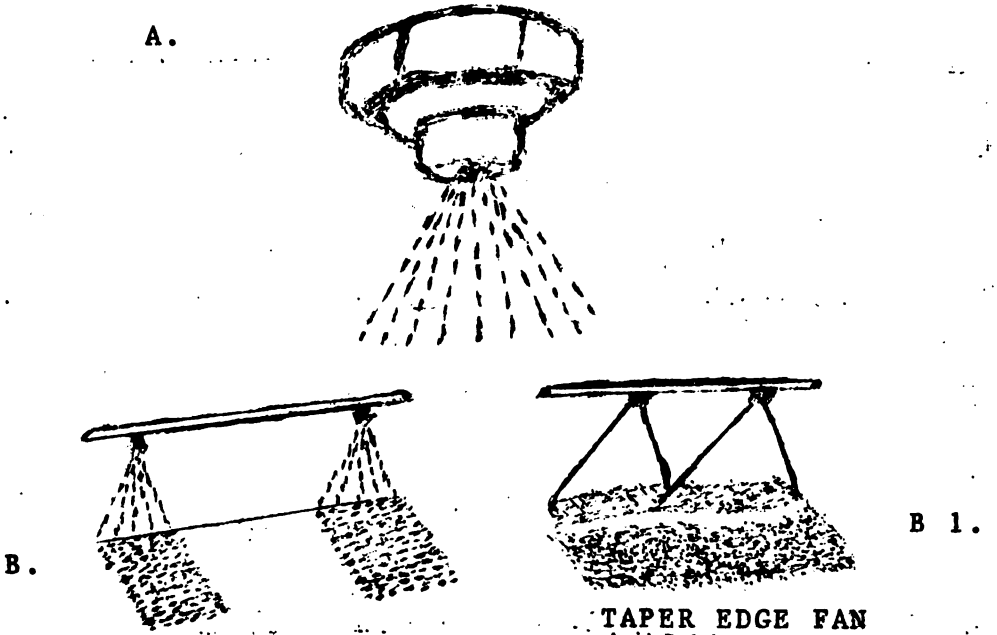

Nozzle
Discharge tube
Hopper cover
Shoulder straps
Dust hopper
Air bellows
Air in-take val-ve
Lever

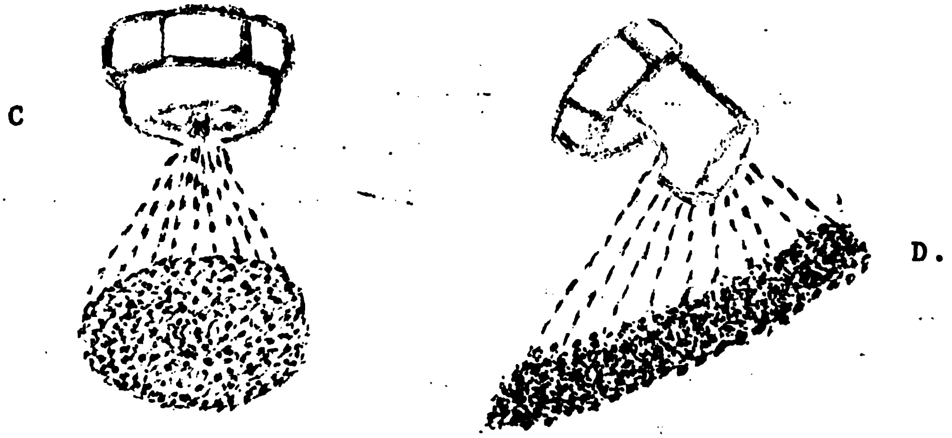
Fig. 15:15

FAN NOZZLES



EVEN-SPRAY FAN NOZZLE

TAPER EDGE FAN NOZZLE



HOLLOW CONE NOZZLE

FLOODJET

Knapsack sprayers - are pumped continuously during spraying. Before starting it should be pumped up until the handle is stiff. One or two strokes every 5 steps during spraying would be satisfactory for keeping the sprayer at the required pressure. In these sprayers, the pumping handle might be on the left or right side of the sprayer. Most right-handed people find it easier to pump with the left hand and hold the hose and nozzle in the right hand. For this reason, most knapsacks have the handle on the right side.

(15:14) A - Compressed - air sprayer B - Knapsack sprayer

Nozzles - The spray leaves the sprayer and is applied to the field through one or more nozzles attached to the equipment. The two main types of nozzles are - fan nozzles and cone nozzles.

(15:15) (a) Fan nozzle (c) Cone nozzle (b) Two nozzles on a single bar

(d) Floodjet

The fan nozzle gives a wider spray and is more suited for applying pesticides. Where a narrower width spray is desired as in using contact weedicides, a cone nozzle should be used between the rows.

In some cases, more than one nozzle is put on a single bar and attached to the hose from the spraypan. This enables the spray to be applied more quickly as a wider area is sprayed at a time. Most nozzles can be adjusted to give a range of width and fineness of spray.

Mistblower. - are sprayers that have an engine attached for pumping the spray. They give a very fine spray and are used for low volume spraying. These sprayers take much less time to spray a given area and the speed of the engine can be adjusted to suit the requirements of the operator. Like pneumatic and knapsack sprayers, mistblowers are carried on the back of the operator while spraying. These small sprayers usually have a capacity of 2-5 gallons (7½ -19l) of spray.

(15:16) (a) Compressed air sprayers (b) Knapsack sprayer (c) Mist blower

Mistblowers spray much more quickly, but are more expensive, less reliable and usually heavier than other portable sprayers. However, the fact that it needs no pumping by the operator makes it desireable for most vegetable growers who have to spray up to an acre each week. Most farmers and their wives complained bitterly of how tired the man usually is after a days spraying with either the pneumatic or a knapsack sprayer. A mistblower should help to make life more comfortable for both. Where the individual farmer cannot afford one, then he could co-operatively own one with a few other growers in his community.

Remember this-
5 farmers with $20 each might be able to own what each farmer will need, but no one can afford.

Dusters -

Dusters are used for applying chemicals in powder form. They are mostly for treating a field before planting but are also used in some cases for later pest control. There are 2 main types of dusters widely used by small vegetable growers viz.

(i) Crank - duster (ii) Knapsack duster

These dusters are of various sizes and designs, but generally, each has certain basic features in common.

(15:17) (a) Crank-duster (b) Knapsack duster

Crank-dusters - are carried in front of the operator by means of shoulder straps. They consist of a dust - hopper which can hold 5-25 lbs (3-12 kg) chemical. As the crank is turned, the powder is discharged from one or two nozzles at the same time. Where 2 nozzles are present, the chemical can be applied to 2 rows at a time.

Knapsack dusters - are also carried by shoulder straps, but like the sprayers, they are carried on the back of the operator. As the leaver is moved up and down the dust is discharged from the nozzle.

Guide for safe use of chemicals.

1. Before using any chemical, carefully read the lable on the container. The chemical should be used as directed by the label.

2. If chemical is put in bottles or containers that might be later used by mistake either wash throughly or destroy them after use.

3. Store chemicals in original containers as far as is possible and keep them tightly closed.

4. Never put chemicals in the reach of children and pets or where they might be mistakingly used as food. Some powders closely resemble flour while some liquid concentrates resemble cooking oil.

5. Food, water and containers used for eating, should be properly covered if nearby to an area where chemicals are being used.

6. Do not smoke or eat while dealing with chemicals.

7. Try not to spill chemical on the skin or clothing. If this happens, wash thoroughly and remove this clothing as soon as possible.

8. Wash face and hands with soap after each application. Try to avoid wearing the clothes for more than two applications before washing.

9. Avoid inhaling chemical whether as dust or spray. During all applications of chemicals to fairly large areas, wear protective masks over the face, clothing and gloves.

10. Do not throw unused chemicals or recently used containers where they might contaminate streams or sources of drinking water.

11. Dispose of empty containers where they will not be re-used unless they go through a process of thorough washing.

12. Always use separate equipment for spraying pesticides and for weedicides.

13. Carefully check the residual effect of the chemical so that a crop is not harvested before the residual effect wears off.

14. Keep a record of spraying done on the farm i.e. area sprayed date and material used.

15. Never use your hand to mix the chemical. Should symptoms of illness occur after an application, get medical attention as soon as possible.

Note - Careless use of chemicals is one of the quickest ways to the grave. Weedicides kill plants, pesticides kill aniamls, there is no reason why if carelessly used, they should not kill man. Afterall they do not seem to respect life!

F. WEED CONTROL

What are weeds?

Controlling weeds is one of the most difficult task that the vegetable grower in the tropics has to face. This is so as weeds grow rapidly and if not controlled, can wipe out a crop, especially in its early stage. But before we discuss this further, we should ~~all~~ be clear as to what weeds are.

Weeds are plants growing where they are not wanted.

Example. If we plant a crop of pepper and find grass growing in the field, then the grass is a weed. Most people know this, but here is something that few people know. If we plant a field of grass and find pepper growing in it, then the pepper is a weed./ Most weeds are classified as broad-leaf plants or true grasses. Some common broad-leaf weeds are milk-weed, broom, wild vines, watergrass. Some true grasses are guinea grass, sour-grass, para-grass.

Importance of weed control

1. Weeds compete with the vegetable crop for air, light, water and nutrients. By robbing the crop particularly of water and nutrients they might -
   - (a) wipe out the crop almost completely if weed growth is rapid in the first weeks after planting.
   - (b) reduce growth and yields considerably if the weed growth is rapid after the crop is well established.

Both situations make it difficult to grow a crop. We can understand more fully how much water and nutrients the weeds will make unavailable to the crop if we compare the population of weeds to that of the crop.

For instance, an acre of cabbage might have 35,000 plants and 25 - 50 times this amount of weeds a month after planting. Then calculating at 50 times this amount it would be 35,000 cabbage plants to 175,000 weed plants. Weeds must be well controlled for growing a crop economically and for getting better yields.

2. Weeds in furrows presents the free flow of water for irrigation and drainage where furrow irrigation is used.

3. Weeds may act as host for insects that damages the crop by feeding on it. These pests spreading certain diseases from one plant to the other. It is because of this that it is important for the grower to control weeds both in and near to the field (eg. edge of field and on canals).

4. Where weed growth is heavy, land preparation is more difficult. Sometimes although the weeds can be ploughed under, if they do not break down easily, furrowing is more difficult. Here the weeds sometimes hitch under the ridger and makes it very difficult to furrow the place properly.

5. Heavy weed growth makes reaping more difficult. Besides, weedy fields are more humid (damp). Disease and insect attack both on fruits and the plant will be greater.

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* Recent experiments carried out in Jamaica and Trinidad show that weeded plots of beans gave about 25% greater yields than unweeded plots. But for carrots, kale, onions, and peas, the difference was from 65% to 85%. Crops with small seedlings or late germination suffer most from weeds.

* (Ref. Weed control in Vegetables - by Dr. Hammerton, Seminar JSA. 1974.)

Ways of controlling weeds

There are 3 main methods of controlling weeds viz.

- manual control i.e. weeds are killed by cutting down or digging them up. (or hand-weeding)
- mechanical control i.e. weeds are cut down or ploughed into the soil by a tractor.
- chemical control i.e. weeds are killed by spraying a chemical on the plant or its seeds.

In weed control, it is not a question of using one or the other, but when necessary, different methods should be used together. Weeds can also be controlled by using mulch. As we saw earlier, this is not the primary function of mulching.

(15:18) (a) hand-weeding (b) mechanical and (c) chemical weed control

Hand-weeding.

This is the oldest way of controlling weeds and is most widely used by small farmers. In this, tools like cutlass and hoes are used to cut down or dig up the weeds. The main draw-backs to this method are:-

1. It gives poorer weed control as in most cases, the root and a small portion of the stem is left intact. The weed quickly grows back.
2. Extra care has to be taken to avoid damage to the crop whether from cutting it down or damaging its root system in pulling up weeds.
3. Like most manual labour, it is slow, expensive and difficult for the people using the tools.

Most of the swellings (corn) and the wounds that peasant farmers have in their hands are the results of years of hand-weeding. Because it is difficult, it would be best for the small farmer to keep the use of manual weed control to as little as possible and use as much mechanical and chemical control as he can afford.

Mechanical control.

In mechanical control, a tractor is used with special implements attached for ploughing between the rows. The weeds might be turned under the soil or the whole plant cut up and worked into the soil in the operation. This is called inter-ploughing and is discussed in more details.

Remember that earlier we saw that distance between rows at planting should allow for mechanical control. If a short crop is to be grown, harrowing the field twice might either reduce or eliminate the need for weeding.

Chemical control.

Using chemicals is the most recent and efficient way to control weeds. These substances either prevent the growth of the seeds or dehydrate (dry-up) the established weeds without harming the crop if properly applied. They are called weed-killers, weedicides or herbicides. All three names can be used at will.

Advantages in using weedicides.

1. Weedicides are mostly applied by spraying. This makes the operation a speedier one. A man can spray an acre of land more quickly than he can either hand-weed or inter-ploughing it. Some weedicides can be used in a granular form.

2. It requires less labour and it may costs less for each weeding. Even where each application is more costly than with other methods, because of residual effect using weedicides might still be cheaper.

3. Some weedicides have a long residual effect and this reduces the number of weedings needed during a crop. Sometimes a single application might control weeds for 2-3 months. With manual control, weeding might be required every 2-4 weeks, with mechanical 3-6 weeks depending on the weed growth.

4. Certain weeds can be effectively controlled only by use of weedicides. Some weeds (eg Pusley) will grow from cutting. When manual or mechanical weeding is used, although the plant is cut down the weed can still grow into a new plant from pieces of its stem. Other weeds (eg nutgrass) can grow from small tubers and for the same reasons is most easily controlled by chemicals developed for such purposes.

5. Weedicides can control weeds effectively along and between the rows. Here it is necessary to choose the chemical suited for such control in each crop.

6. Chemicals can be used on a range of soil conditions i.e. wet, dry stony or fairly steep.

7. In some cases, it is possible to apply weedicides and pesticides together. This further reduce the expenses in weed control on the farm. However, this practices is not recommended unless the grower is sure that the chemicals can work together

8. Weedicides also help to take 'the irk out of work'.

Problems in using weedicides.

The greatest difficulty a vegetable grower has in using weed-killers, is that he must know how to apply the chemical properly. i.e.

(i) The right chemical for controlling weeds in the crop he is growing.

(ii) The correct time to apply it i.e. before or after plant.

(iii) The correct method of applying it i.e. how to use it so that it does little or no damage to the crop.

Types of weedicides.

There are 3 main types of weed-killers viz.-

(i) contact, (ii) selective and (iii) pre-emergent. (or pre-em.)

CONTACT WEEDICIDES - These chemicals will kill all green plant material on which it is sprayed. These chemicals will kill both the weeds and the crop if directly sprayed onto the plant. Contact sprays are applied to the foliage of the weeds and within 10-15 minutes, the weeds will start to wilt. 2-3 days after application most weeds would have dried up.

Note - 1. Generally, the higher the rate of application the longer it will take for regrowth of weeds within certain limits. i.e. the higher the ratio of chemical to water, the longer will it take for weeds to grow again, within a certain limit.

Example.

When Gramoxone is applied to a field, it may take from 6-12 weeks for regrowth. The usual recommendation from the manufacturer is 1-2 pint chemical per acre. In the first place, if ½ pt. is used, it will not kill the weeds. When 1 pint is used weed regrowth might take up to 8 weeks under a certain condition. But if 2 pints is used in 10 galls water, weeds might not start growing till 12 weeks later However, if 3 pints are used, the effect will not be much greater than with the 2 pints in the same conditions. Increasing the concentration increases the effectiveness up to a certain point and no further. In addition, drift of the chemical to the plant becomes more serious.

2. Most contact sprays are de-activated (i.e. become inactive) on contact with the soil. They do not have much residual effect in the soil as some other types of weedicides.

Application of contact weedicides.

Contact weedicides are applied after weeds have emerged (post-emergent or post-em.) Extra care has to be taken in spraying the chemical as it will kill both weeds and the vegetable crop if sprayed on to it, When crops are planted nearer than 12-15" between or along rows, it is difficult to use these chemicals in the field. One of the things a grower can do is get a spray shield for applying contact weed-killers.

Spray - shields -

A vegetable grower can either buy a shield or make one for himself. It can usually be made from plastic or from light metal. Plastic that is not very rigid is best as it will do less damage to young plants when working between the rows. Shields can be conical or fan shaped to suit the type of nozzle to be used.

(15:19) Home-made spray shield made from small bath-pan and a fan-shaped plastic shield.

When using shields, the person using the spray can go nearer to the crop without fearing much about drift. The shield keeps the spray down and can be used under windier conditions than when weeding without the shield.

Where it is not possible to work between plants along the row, application should be done between the rows. Hand-weeding can be done along the rows.

Note - It is always wise to test the weedicides in a small section of the field and see its effect, before it is used on a large scale. This can be done 2 or 3 days before the large scale spraying.

Time to spray. - It is best to avoid spraying in early morning when the field is wet from dew as this makes the spray more dilute and less effective. Also spraying should be done when the area is less windy. Wind will blow the spray and might cause damage to other crops from drifting of the weedicide. If a vegetable grower suspects that rain may fall while spraying or very soon after, he should leave his weed control until another day. These points hold for application of most if not all weedicides.

Remember that it is not necessary to use spreader-stickers in weedicide sprays.

Foam spraying - This is a recent development in which the chemical, usually an emulsion, when mixed and sprayed with a special nozzle produces a foam. Foam nozzles and foam spraying produces very little drift, so that spraying can be done on a windy day without a shield. Grammoxone has been introduced in foam sprays. Granular weedicides also reduce the chance of damaging the crop.

SELECTIVE WEEDICIDES - These chemicals when sprayed on thefoliage will kill certain plants but will be relatively harmless to others. They are absorbed by the plant through leaves and stems and this affects the entire plant. Because of this they are also called systemic weedicides. New weed growth is mainly from seeds already in the field. An application of a selective weed killer can therefore effectively control weeds for a longer period than contact weedicides. But unlike contact killers, a systemic weedicide cannot control all green plant material. So that they are divided into 2 main groups viz. :-

(i) Broad-leaf weedicides eg. 2-4D which will kill broad leaf plants and relatively harmless to fine leaf plants. Mallow, marigold, broom-weed, spanish needle, watergrass, nutgrass and vines can be controlled by broad-leaf weed-killers.

(ii) Grass weedicides eg, Dalopon which will kill fine-leaf plants and relatively harmless to broadleaf plants. All true grasses have long-narrow leaves and can be controlled by fine-leaf weedicides.

It is possible in growing a crop of corn to spray 2-4D both on the corn and on the weeds. The broad-leaf weeds would be killed but the corn and the grass in the field would not be killed. If Dalopon however was used, it would kill the corn and the other grasses in the field and leave broad-leaf weeds unaffected. However, the Dalopon can be carefully directed on the grass weeds to control them without destroying the corn.

Similarly, if Dalopon is sprayed on a field of beans, it would kill the grass and would not affect the crop and broadleaf weeds. If 2-4D is sprayed on the same field, it would kill the beans and broad-leaf weeds leaving grass alive. The 2-4D can be used to control weeds affecting a crop which is also susceptible to it, but the chemical would have to be carefully sprayed on the weeds, but not allowed to touch the beans.

Application of selective weedicides.

Systemic weedicides are also applied as sprays, but are applied in a different way from contact weedicides. Because they are selective, the ones choosen for use in a crop would be relatively harmless to that crop. So that the weed killer would usually be sprayed over the entire field.

Where inter-ploughing is to be done, the weedicide should be applied along the rows and the ploughing later done. This reduces the amount of chemical used and the need for hand-weeding along the rows.

PRE-EMERGENT WEEDICIDES -These weedicides are applied to the field before the weed start growing. The crop which would be tolerant to the spray would emerge, but the weeds would not as the spray acts on their seedlings soon after germination. As the sprays are usually applied to the soil these chemicals are also called soil-acting weedicides. Most have a long residual effect ranging from 1-3 months depending on the weedicide and the rate at which it is mixed. i.e. the higher the ratio of chemical to water the longer it will be effective when a certain limit. However, on light soils with rapid drainage and in periods of heavy rainfall, the chemical will be less effective. It will more easily be washed out of the top soil where the seeds of weeds would be concentrated.

Example - Dacthal and Atrazine are pre-emergent weedicides. Dacthal will control weeds for 3-5 weeks, while Atrazine will be effective any where from 8-16 weeks.

Application of pre-emergent weedicides.

Pre-emergent sprays are usually applied to the soil surface either immediately before or after planting. If done after planting, the chemical should be applied before the crop starts to emerge. After spraying the field, it should then be irrigated to allow the germinating weeds to absorb the chemical.

In some cases, a small amount of soil acting spray can be mixed with contact sprays and both applied. About the same amount of each chemical has to be used as when applied separately. This extends the time taken for regrowth of weeds as the pre-emergent spray prevents the growth of weeds from the seeds while the contact spray cannot. Example. Karmex when used with Gramozone, delays weed growth by up to 12 weeks. On the other hand, if a pre-emergent spray is to be applied after some weeds have germinated, then some contact material should be added to kill those weeds.

4. Multi-purpose weedicides - These can be used for controlling both broad and narrow leaf weeds, either as a pre-emergent or post-emergent spray on a number of crops. When used as post-emergent spray, weeds should not be over 1-2" tall. There are few of these chemicals on the market as they have only been recently developed.

Example

Here is a summary for Tok E-25* on vegetables.

Crops	Type of application	Types of weeds controlled
Cole crops Brocolli Brussels sprout Cabbage Cauliflower Kale Turnip	Pre-emergence	Broad-leaf weeds goose foot groundsel malva nightshade nettle pigweed
Onions	Post-emergence	purslance
Carrots Celery Radish Parsley	Pre-emergence or post-emergence	shepherd's-purse spergularia Grass-weeds bluegrass crabgrass

Application of multi- purpose weedicides

The way the spray will be applied will depend on whether the chemical is to be used as a pre- or post-emergent spray.

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* Ref: - Rohm & Haas publication -Feb. 1970.

Which weedicide should I use?

A vegetable grower who plans to use weedicides should first ask this question. He has to decide-

- firstly, what type of weedicide to use i.e. contact, selective or pre-emergent
- secondly, which weedicide from selected group to use.

In deciding these, he has to think of two main factors viz.-

- the crop to be grown.
- the type of weeds to be controlled.

Contact

In determing the type of weedicide to use, the vegetable grower should remember that contact sprays can be used to control nearly all weeds. The main problem is to keep it off the crop. This means that for most crops, it cannot be used for control between plants along the row. Hand weeding is therefore also needed. In addition, regrowth of weeds is much quicker so the number of applications would be more than if a systemic or a pre-emergent spray was used. So that one of the other two types might be choosen over a contact killer for economic reasons.

Selective

A selective weedicide has a drawback in the fact that weeds are usually mixed. It is rare that we plant a field of corn and find broadleaf weeds, but no grasses. For this reason, they also have to be supplemented by hand-weeding both between and along the rows. But one does not have to worry too much about the weedicide damaging the crop except when the wrong one is used. Also, they may take a few weeks to be absorbed in sufficient quantity to kill the weeds. Heavy rains within a hour after application reduce their effectiveness.

Pre-emergent

Soil acting sprays are very effective when a suitable one is found. But farmers have complained that after using a pre-emergent sprays to grow one crop in a area of the farm, it sometimes has adverse effect on a different crop later grown in the same area. Atrazine for example has proven very good for weed control in corn. But after it is used in an area for a time, it might be difficult to grow a crop of bean after reaping the corn. Small vegetable farmers with limited land has to make sure that any of the crops he is growing can be safely planted anywhere he reaps another crop.

However, when used, a single pre-emergent application eliminates the need for weeding particularly when the crop is young. Depending on the strength of the mixture it might not be necessary to weed again throughout the entire crop. This usually helps to make it the least expensive type of weedicide to use. These weedicides usually remain near to the surface of the soil, when inter-ploughing or moulding is done, the effectiveness of the spray is reduced.

Multi-purpose

In deciding whether or not a multi-purpose weedicide should be used, the vegetable grower has to consider mainly the cost of using this type of chemical. This should be compared with the cost of using another type that can also effectively control weeds in that crop. Remember that multi-purpose weedicides are usually more expensive than other weed-killers. If for instance, a pre-emergent spray can control weeds in a crop as much as the multi-purpose spray, it would generally be less expensive to buy the pre-emergent spray. For example, Tok (multi-purpose) and Dacthal (pre-emergent) can both be used effectively in beans. Where possible the pre-emergent spray should be used.

Which weedicide?

After deciding on the type of weedicide to use, the question of which one to use is not very difficult to answer. Two steps should be taken.

1. Choose a number of weedicides that can be used on that crop for the soil condition on the farm.

2. Choose the most economical one from comparing
   - the price of a given quantity of the chemical
   - the quantity that will be required for controlling weeds in the area
   - the lenght of time for which it can effectively control weeds. This will determine the number of applications needed for the duration of the crop.

How much spray is needed?

In chemical weed control, as we have seen, it is important that the grower use the correct rate or the quantity of weedicide on the area to be sprayed. The amount of water in which this is mixed should be enough to cover the area evenly.

The rate of applying the weed-killer is recommended by the manufacturer and written on the label of the container. The amount of water in which this is to be mixed, usually varies between 10 to 40 gallons depending on type of equipment, type of terrain etc. But the actual amount of water to be used can be worked out by spraying a gallon of water in the field to be weeded. Mark out the place sprayed and calculate the area.

(15:20)

Sq. Yds. sprayed with 1 gallon	Gallons per acre	Sq. metre sprayed with 4 litre	Approx litres per hectare
120	40	100	400
150	35	125	350
180	30	150	300
210	25	175	250
240	20	200	200
360	15	290	150
480	10	380	100

Here is a table showing some of the most commonly used weedicides, their residual effect and the generally recommended rates for mixing them. The rates at which each can be safely used will vary with the crop, soil texture and stage of growth of the weeds to be controlled. The manufactures recommendations are to be carefully followed.

(15:21)

WEEDICIDE	Other Name (s)	Rate per acre* or per. ha.	Weeks of weed control
Contact			
Gramoxone	Paraquat	1-2 pints/	6-12
Reglone	Diquat,	(2-4 litre)/ha.	
Round-up'	Glyphosate		8-12
Selective			
Dowpon-S	Dalapon, Gramevin	(7-14 kg/ha) (7-14 lbs/ac.)	8-16
Kuron	2,4, 5-TP		
Tordon			
Weedone	2,4-D	1 2 pints	6-12
		(2 - 4 L)	
Pre-emergent			
Amiben	-	4-8 pints	4-8
Dacthal	-	3-5 lbs or kg/ha	3-6
Dymid	Diphenamid	3-5 lbs	3-6
Dybar	-		
Eptam	-		
Gesagard	Prometryne	2-3 lbs	4-8
Gesaprim	Atrazine	2-4 lbs	8-16
Gesapax	Ameltryne	2-4 lbs	4-8
Hyvar-X	Bromacil	2-4 lbs	12-20
Kerosene	-	30-100 galls	2-6
Karmex	Diuron	2-4 lbs	8-16
Lorox	Linuron	4-6 lbs	4-8
Stodard	-	30-100 galls	2-6
Varitox	Sodium TCA	5 lbs	6-10
Multi-purpose			
Tok E-25	Nitrogen	4-8 pints	3-6

Pre-plant (weed) control.

What is the pre-plant control and why use it?

Pre-plant weed control as its name suggest is one in which the weeds are controlled either before the crop is planted or before seedlings have emerged. It is a reasonably safe method of chemical control that can be used by growers not familiar with using weedicides. In addition, peasant farmers have to be careful in using pre-emergence sprays for a long period in a given area. Because these vegetable growers have limited land space, and have to shift their planting continuously, after a number of planting and pre-emergence spraying in the same area a crop might be planted and it does not grow well. This is so as the pre-emergent sprays have a residual effect in the soil and like all chemicals of this type, it tends to build up in the soil. So that while use of pre-emergent sprays should be recommended, a vegetable grower might do well to avoid long use of these sprays in a given area.

While it is not recommended to use pre-plant control for all plantings, the small vegetable grower should use it occassionally as substitute for pre-emergence. As we will see later, it takes some amount of extra time which might set back the planting plans of the grower.

What to do?

1. Prepare land for planting
2. Irrigate the field after preparation or wait for rain.
3. As soon as weeds are seen to start growing, plant the seeds. A check should be made on the expected number of days to emergence, and planting done to allow most weeds to emerge before crop.
4. About 2 days before the crop is expected to emerge, the field should be sprayed with a contact weedicide. By this most weeds would have fully emerged. To make the control more effective the contact weedicide should be mixed with a suitable pre-emergent one in a 3: 1 ratio. (i.e. 3/4 contact + ¼ pre-emergent). If the crop is not being grown from direct seeding but peat pot or

from transplant, the weeds should be sprayed immediately before planting the crop.

5. Irrigate about 2 days later and grow the crop from applying practices in the usual way. A short crop might be grown with only a minimum of weed control needed. Usually hand-weeding would be sufficient to control later weed growth. For longer crops inter-ploughing would take care of any futher needs for weed control.

Problems in using pre-plant control

1. Looking at pre-plant control, we will see that the major problem in using it, is the fact that it might be necessary to wait 1-2 weeks before planting the crop. If it were to be used regularly, then it could affect planting and reaping plans. For instance, where it were possible to grow a crop in 10 weeks, it might now take 12 weeks. The word might is underlined as the fact that in early growth there will be no weeds to compete with the crop, could actually make reaping possible at the same time if not earlier.

2. The second problem is that on heavy soils, addition of water (irrigation or rainfall) before planting will make planting more difficult. This is so as the soil will now not be as loose as when planting is done immediately after land preparation. One way to tackle this problem is plough and harrow first, then open the furrows at planting i.e. for hand-planting, peat-pot and transplanting. Better yet, would be to give a light harrowing while opening the furrows at the same time.

Equipment used for chemical weed control

All equipment used for mixing and spraying weedicides should be used for weed control only.

The statement above should be read at least twice so that we can all be clear about what it says. Quite often, vegetable growers have their crops set back because they used the same spraying equipment for pest and weed control. It is extremely difficult to wash out weedicide from a container. So in spraying an insecticide on the crop using the same equipment to mix and spray weedicide, the grower will be spraying traces of weedicide also on his crop. This will damage the crop.

Some weedicides are so difficult to wash out of the container that if they are used often, separate equipment should be used for spraying them. 2-4D is the most common example. A separate pan should be used for mixing and spraying it.
Here are some key points.

1. Equipment used for chemical weed control should be stored separately or clearly marked. Use paint to mark "WEED" on these equipment.

2. After each spraying operation, wash out the equipment used thoroughly. Soap powder and water will be good enough for most weedicides. Leave the equipment full of water over night to make sure the weedicide is removed.

3. Mistblowers are not best for applying weedicides as their fine spray cause the chemical to drift and generally difficult to control. Where it does not damage the crop sprayed it might damage nearby ones. If a kind of spray-shield could be devised and the engine run at low speed, then mist-blowers would be more suited for applying weed-killers.

Chapter 1 REAPING AND MARKETING

A. REAPING

Reaping is one of the last jobs in producing a crop. In this the grower picks fruits, cuts leaves and pull up tubers depending on the type of crop This is some-times the reward for long days of working brain and body and long nights of working the brain on various plans for growing the crop. The word "sometimes" is underlined as there are times when parasites, both human and otherwise, prevents the grower from reaping a crop although he planted one. However, when the vegetable grower gets a chance to reap a crop, it should be properly done.

Importance of proper reaping

1. Return from the crop depends on its appearance, quality and total weight. If it is not properly reaped, these 3 factors cannot be at their best.

2. If a crop is not properly harvested, the total sales of the grower will be reduced. Either the price of the produce will be lower or the quantity will be less than if it were reaped properly. At this stage, most if not all that are required would have been spent on the crop. Because of this, the grower might suffer a greater loss than if for example disease had destroyed the crop in early growth.

(16:1) a. (op) and
b. (elow) ready for reaping.
c. Reaping

How to ensure proper reaping

1. Reap at the correct time.
The housewife buying vegetables considers 2 main things, viz, quality and price

The vegetable grower should also look at these points in reaping his crop. Those readers who have long memories, will remember that these were mentioned as important in selecting what varieties to grow.

The vegetable grower to reap his crop properly should make sure that he reaps as much good quality produce as is present.

Good Appearance	-	hard or soft, smooth or granular, fibrous or without fibre depending on crop.
High Texture	-	taste and smell good.

Highest Quantity of good quality produce.

<u>These 4 conditions can only be fulfilled when the fruit is mature, but they do not automatically go together.</u>

<u>Example</u>.

Reaping Polmar cucumber 7 weeks old, the quality of each fruit might be good, but it weighs only 6 ozs. But if it were reaped 8 weeks, the quality would still be good, but it would then weigh about 12 ozs. and if it were allowed to stay for another week it probably would weigh 16 ozs, but its quality poor.

So that it would be best to reap the crop at 8 weeks when the quality is good and the quantity also high. The crop is also mature then.

2. <u>Use the correct reaping method</u>.

But suppose the grower in reaping tries to pull 2 fruits from a plant at a time and in so doing damages his fruits, OR, suppose he tries to pull up the heads of lettuce instead of cutting them, then he would do serious damage to his produce in this way. So that although he might be reaping the crop when the quality and quantity are at an optium, then he still would not be reaping his crop properly. The same is true if he reaps his field without reaping all his mature fruits.

3. Reap at the correct time of day

Most vegetables lose quality very rapidly at high temperatures. It is best to reap when the time is cool. Reaping in the morning is the best time as some crops will wilt when harvested in the afternoon. Growers who find that they have to reap large quantities would do well to start earlier in the morning so that by mid-day at the latest reaping is complete. This might not be necessary in all cases as in elevated areas or in the cooler months on the plains, reaping can be done throughout the day.

4. Use the correct reaping interval for the crop.

(a) The length of time between one reaping and another will vary from one crop to the other. Carrots and beets for example, might allow an interval of over a week. On the other hand, okra, string beans, cucumber have to be reaped every 2-4 days.

(b) Reaping intervals also varies with the stage of reaping. i.e. while string beans have to be reaped every 2-3 days in the first 2 weeks of reaping, in later stages it might be necessary to reap only once per week. i.e. the reaping interval will increase.

So here are the key points in reaping.

Reap the crop at the correct time i.e.

1. reap when it is mature.
2. reap when quality is good
3. reap when the quality is the highest amount that is of good quality.
4. reap at the correct time of the day.
5. allow the correct reaping interval.
6. Use the correct reaping method. i.e.
6. use a method that does not cause damage to the produce.
7. make sure that the field is reaped clean of mature produce.

The table below, gives the approx. time to 1st and final reap from planting, also yields to expect from some vegetable crops. Remember that these factors will vary from one farm to another depending on things like soil type, fertilizers used and management.

(16:2)

CROP	Time to 1st reap-		Average pe-iod of reaping (wks)	Expected Yields (s. tons/acre)*	
	Early varieties(wks)	Late var. (wks)		Average	Good*
Beans (snap)	7- 8	10-12	3-6	1 ½ -2	3-4
" (kidney)	9-10	12-14	1-2	1/3-½**	3/4-1
Beet	7-8	10-12	4-6	3-4	5-8
Brocolli	10-12	16-18	3-6	2-3	4-5
Brussels spout	12-14	14-18	4-6	3-4	5-6
Cabbage	10-12	14-16	4-6	3-5	6-8
Calalloo	7-8	-	8-12	4-6	
Carrot	8-10	12-14	4-6	3-5	6-10
Cauliflower	8-10	10-12	2-4	2-3	4-5
Celery	9-12	14-18	2-4	3-4	5-8
Chard	7-8	8-10	2-4	3-5	
Corn (Green)	10-12	12-14	2-4	4-6	7-8
(dry grain)	14-16	16-18	1-2	1-1½	1½-2
Collard	10-12	12-15	2-4	2-4	4-6
Cucumber	7-8	9-10	4-6	3-5	6-7
Endive	10-12	-	3-4	2-4	
Escallion	10-12	-	4-6	1-1½	2-3
Garden-egg	12-14	16-20	6-8	3-4	4-5
Kale	8-10	12-14	2-4	2-3	3-4
Kohl-rabi	8-10	-	2-4	3-4	5-6
Leek	12-14	14-16	4-6	3-4	
Lettuce	6-8	10-12	4-6	3-5	6-8
Musk-mellon	12-14	-	4-6	4-5	5-6
Mustard	6-8	-	2-4	3-4	4-5
Okra	7-8		10-12	2-3	3-4
Onion		14-18	2-4	4-6	8-10
Parsley	9-10	11-12		2-3	4-5
Parsnip	12-14	16-18	3-4	4-5	6-8

contd.

CROP	Time to 1st reap-		Average period (weeks)	Expected yields (tons/acre)*	
	Early var. (wks)	Late var. (wks)		Average	Good
Pepper	9-10	10-12	4-8	1-2	2-3
Peas	8-10	10-12		1/3-½	3/4-1
Potato	12-14	14-16	once	4-6	7-8
Pumpkin	12-14		6-8	5-6	7-10
Radish	3-4	-		5-7	
Soyabean	10-12	12-14	once	1/3-½	3/4-1
Spinach	5-6	6-8	8-12	5-6	
Squash	8-10	12-16	4-6	4-5	6-8
Tomato	10-12	12-14	6-8	4-5	6-8
Turnip	6-8	9-10	2-4	3-4	5-7
Watermellon	10-12	12-14	4-6	4-6	7-8

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* Good yield figures are from higher yielding varieties.
For legumes and grains, approx. 30 bushels ≅ 1 s. ton (2000 lbs)

** Multiply yields in tons/ac. by 2 to get approx. tonne/ha. (or multiply by 2.25 to get exact conversion).

Maintaining the crop during reaping.

Care should be taken of the field while the crop is being harvested. i.e. irrigation, weed and pest control might still be necessary. But the grower will have to look into his situation and decide to what extent these are necessary. For instance if weeds are even high, and the crop is in its last week of reaping, then it is only a mad farmer who would think that weeding then would benefit the crop. But with irrigation and pest control, it is a different story. Because whether first or last week, the crop needs moisture to grow and if the soil is getting dry, the field must be irrigated. If this is not done, the plants might drop their fruits. But over-head irrigation must be applied lightly as heavy application would beat off flowers and fruits.

If pests are present, they should be sprayed. But only the safest pesticides i.e. the ones with the shortest residual effect should be used. If reaping is to be done in 5 days time, it is best to use either pesticides that have no residual effect or 3 days at most. Remember that these chemicals do not respect human life. An individual who is not careful in using them particularly during reaping might find himself charged with manslaughter, if he had not also commited suicide. (i.e. from selling and eating poisonous food).

Clearing after reaping.

When reaping of a crop has been completed, the remains of the crop should be cleared from the field. This is a measure that will be of considerable benefit to crops not yet reaped and later plantings.

How? - Well the remains of crops are as attractive to insects and diseases as the crop, during its growth. As a matter of fact, it might be more attractive to these and other pests. In addition to the foliage, there is usually a considerable amount of bits of fruits and whole ones, in the field. So that the remains of the crop will act as a reservoir for insects, diseases and other pests.

A field of tomato for example, in a week after reaping will have almost every type of insect and diseases attacking it. These can spread to other crops growing on the farm quite easily. But more dangerous is the fact that some of these lives in the soil, and will build up their population in that area. Then the crops planted there later will have a hard time to survive pest attack.

The vegetable grower will have a harder time buying more chemicals and paying more for applying these. Then the beauty of it all is that he might be fighting a loosing battle as some diseases for example, cannot be successfully controlled once they are well established in the area. To avoid all this, the vegetable grower would do well to clear his field as soon as possible after reaping.

What to do?

How the field can best be cleared will depend largely on the type of crop. But for most crops, one of these suggestions below should work.

1. Cut the remains, remove it from the field and feed it to animals. Where possible, it is better to bring the animals into the field to feed on the material.

2. Cut the remains and use it for composting. This is most suited when there are no animals on the farm or where the animals will not eat it. This should also be done when the crop is not fit for the previous suggestion.

3. Plough in the remains. This is the means of clearing that should be most often used. We can see that this is really double blast from a single barrel shot gun. We kill two birds with one shot in clearing and ploughing in a single operation. This is really clearing, ploughing and adding green manure all at once. Matter of fact, it seems as if we are killing 3 birds with one shot!

B. MARKETING

Preparing for market.

After the vegetable grower has reaped his crop, before he actually sells it, it is necessary to do certain jobs. These will make his crop sell more easily and at higher prices. They include:-

1. Trimming and Washing

2. Grading and Packing

3. Storing

4. Transport to market.

Trimming and washing

When crops are reaped, they usually are in a condition that is not fit for marketing. Sometimes the produce has parts attached that have to be removed before the crop is sold. i.e. trimming is needed. When the produce is dirty, it needs washing. Cabbage is usually reaped with outer leaves that needs to be trimmed, while cucumber might be dirty and needs to be washed. Some crops, like turnip and most root vegetables might need both trimming and washing after harvesting.

Trimming and washing are needed mainly because-

1. By trimming, the produce can be more easily packed and reduces the quantity of material to be transported. By reducing the quantity, then the cost of transport will also be less.

2. By trimming and washing, the product is made more attractive. Remember that appearance is very important to the housewife. i.e. the more attractive the produce, the better price the grower will get.

Reaping a crop we will notice that the fruits are of different sizes. and quality . In some crops, for example Beans, the difference in the size of the fruit might not be as noticable as that of tomatoes. Before marketing, crops that show a marked difference in the size and quality of their produce needs to be graded i.e. in grading certain standards are set and the fruits grouped according to these standards. The standards or grades are usually agreed on by the grower and the person buying the crop. In other cases, it is set by the government marketing agencies.

Example*

Grading for sweet pepper bought by the AMC of Jamaica are as follows:-

Grade 1. Consisting of sweet peppers that are:-
(a) of similar varietal characteristics,
(b) mature-green, form, well-shaped,
(c) free from sunscalds, decay and damage caused by scars, diseases, insects, mechanical or other wise
(d) generally of good marketable quality.
Size: Diameter not less than 3 inches

Grade 2. Require the same as grade 1 except size.
Size: Diameter not less than 2½ inches

Tolerance: Not more than 10% in any lot may fail to meet the requirements of these grades, not more than 5% of any lot shall be allowed for peppers which are seriously damaged and not more than 2% for peppers affected by decay.

Definitions: (These explain the terms "similar varietial characteristics" mature-green, "form","well shaped" and "damaged" fruits.

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* This example is taken from a booklet "Standard Grades for Crops" published by Agricultural Marketing Corporation (Jamaica-1970).

The way crops are graded are different in different countries and different places, in the same country. But where ever crops are sold, the higher grade produce get higher prices. When a housewife take up two heads of cabbage of the same size, she says she will pay 20¢ for one head and 30¢ for the other, what she is doing is really grading the produce. She decides to pay more for the one with higher grade. But right away, you could ask, is'nt she deciding the price on the weight of each head? The answer to this is yes and no. If we look at the examples above we will see that grading is done according to the size of the produce and the quality.

Grading is usually done on the farm at the same time as packing i.e. produce of the same grades are put together in containers for marketing. In most cases grading and packing is done by the vegetable farmer, but this is later checked by the agency or by the individual that is buying the crop. This has to be done as some farmers are known for packing stones in the boxes with vegetables on top.

The grower should try to avoid packing more than one crop in the same container. However small farmers sometimes are short of boxes and have to do this. Common sense should be used and the harder crop put at the bottom of the container. A grower who puts his cabbage on top of tomato in the same box might not like what he sees when he reaches the market.

(16:4)

Stóring

Tropical vegetable farmers sometimes loose because of the way they store their produce. Some crops, leafy vegetables mainly, are reaped and sold either the same or the following day. It is not necessary to store them for long periods, But other crops like potato, onions and some legumes have to be stored for sometimes over a week. In some cases, the crop is stored for curing or for drying while at other times a ready market is not available.

Here are a few points that should be of some help.

1. Store the produce in a cool place
2. Stores where it will not be easily attacked by insects or other pests.
3. Store where it cannot be contaminated by chemicals.
4. Store out of the reach of animals.
5. Spray leafy vegetables with water to keep them fresh.

Transport to market

When it is necessary for the vegetable grower to transport his produce to market, he should try to do this in the safest and at the same time, the most economical way. Carrying the produce on a donkey might be the safest, but not the most economical way, as it might take several days to transport it this way. But despite the mode of transport, whether truck, train or donkey, the grower should make sure that his crop reach market with little or no damage. The more damage the produce gets, the lower will be the price for which it can be sold.

Marketing -

At marketing, the vegetable grower sells his produce. The price he gets depend mainly on the crop that he is selling and on the overall quality of such yield. But this might always depend on the type of arrangement that the grower makes for selling his produce. These have been discussed in Sec. 3 , but to refresh our memories, the main marketing arrangements are:-

1. Direct sales in which the grower sells his vegetables directly to the consumer.
2. Indirect sales in which the grower sells his produce to another individual or agency who then will sell to one consumer. This would include contract sales in which the produce is supplied according to an agreement made before the crop is reaped.
3. Contract sales to marketing agencies, factories, restaurants etc.

KEEPING NOTES AND RECORDS

Chapter 17.

Simple notes and records can be kept and must be kept by all vegetable growers who intend to operate their farms successfully. There is no reason why even a peasant vegetable farmer who is unable to read and write cannot keep records. He cannot read and write but his wife or at least one of his children can. Keeping notes and records tell the grower, what way his farm is moving - backward or forward and an indication of the reasons for such movement. They can also provide information needed for greater forward movement.

A. NOTES.

Notes are supplements to records. They are usually kept by the student of vegetable growing, but neglected by the farmer. They are important for all in scientific vegetable production. The records while giving exact figures of production, expenses etc. (i.e. economics of the farm), the notes will give additional information as to why the figures are so. For example the records might show high total production but low sales. This might well puzzle the grower, but his notes will say - fruit description : poor quality.

Here is a list that will give the grower some idea of the type general notes that might be kept. A small hard-cover note book or a diary should be used to keep weekly notes. The diary is the better one for farmers. (Students doing special trials will need more specific details.)

Name of crop.
Name of variety
Date planted
Area of plot (on which crop planted)
Planting distance
Fertilizer (Type & Amt)
Weed Control
Rainfall and Irrigation
Crop deficiency signs.
Insects and disease. (control & how successful)
Date of first reaping.
Date of final reaping
Fruit description -

Other notes - This would include added notes of interest to the grower. For instance if liming was done or mulching, problems and how these affect the crop.

B. RECORDS.

Records are the yard-stick that measures the operation of the vegetable farm. They tell whether the farm is moving backward or forward and are as important to the farmer as it is to the student. The farmer who does not keep records, might not find out that his business is moving back-ward, but he will certainly find out when it has moved backward, sometimes behind where it started.

Types of records.

Two types of records would be very important to all vegetable growers.

1. Cost of production (c.o.p. records).
2. Sales of product (ion) (s.o.p. records).

Records of cost of production (c.o.p. records).

Cost of production records might be kept for each crop on larger farms, but should be kept for the whole farm when smaller.

Why keep cost records?

(1) To know spendings or expenses on each crop (or whole farm) i.e. weekly and total expenses.

(2) To be used to work out profit from each crop (or whole farm)

The farmer should include his own labour and members of his family who also work on the farm under his expenses.

C.O.P. MODEL

This model can be of use to the vegetable farmer or student wanting to know the performance of an individual crop on the farm.

Like the S.O.P record model and all others, it is intended only to be a guide as both students and farmer can design their own models.

This simple model should hold on two pages facing each other in a pocket-size hard-cover note book or diary.

(17:1)

COST OF PRODUCTION RECORDS

Crop: CABBAGE

Cost for w/e	7/1/	15/1/	21/1/	28/1/	4/2/	11/2/	18/2/
Materials							
Seeds	$7						
Fertilizer	42					30	
Insect & Fungicide	10						10
Weedicide	23						23
Other materials			10				
Labour*							
Land Preparation	100						
Fertilizing	45						30
Transplanting	120	5					
Spraying			15	5	5	15	5
Reaping							
Other labour		5	5	10	5	5	
Other costs	30	10		30		20	20
Fixed cost** Land, equip. etc.	20				20		
Totals	397	20	30	45	30	70	88

*(Labour calculated at $5 per man day)

To understand how the model can be used, it is best to look at the example

1. The totals at the end of each row of the cost sheet will show the amount of money spent for each item listed. The totals at the bottom of each column gives the total spent on each week end. The grand total spent for the period is given in the box to the extreme right of the sheet.

2. The cost figures are used with sales to find the profit. In this example the cost of production for the cabbage is

$$\$870 \div 1\tfrac{1}{2} = 870 \text{ x } \frac{2}{3} = \$580 \text{ per. acre}$$

Sales of product.

These are records of the quantity reaped and what the grower gets from this. The production figures are very important.

1. The yield for the crop can be found by dividing the quantity reaped by the acreage of the plot reaped. Quantity ÷ Acreage = yield.

2. Total Production and yields of each crop will give the grower some idea of production to expect in later crops. This will help in making market plans.

3. Total Production of different varieties of the same crop can be got from these records over a period.

4. Sometimes the figures for costs and returns show that a crop is less profitable than another. But this might be due to a fall in market prices and not low yields when the market conditions change. The grower can go back to producing his high yielding crop.

Or, it might be that fruits have been badly damaged by insects or poor reaping practice. But if the grower can remedy these, then his production records will indicate if this will give returns.

The sales from a crop are calculated by multiplying the quantity sold by the price.

SALES OF PRODUCT (S.O.P Model)

(17:2) Crop: Cabbage Date planted*: 15th Jan.

Variety: Early Jersey Plot size: 1½ acre

Date	Production	Price (cents/lb.)	Total sales ($)
2nd March	350 lbs.	15 ¢	$ 52.50
6th	720	12	86.40
11th	1480	10	148.00
14th	2520	10	252.00
18th	3700	18	296.00
24th	2070	10	207.00
27th	730	12	87.60
30th	410	14	57.40
1st April	100	15	15.00
	-	-	-
TOTAL	12080 lbs	(Av) app. 10 cents	$1,196.90

YIELD = 12080 ÷ 1½ = 8050 OR app. 4 tons per acre.

The Profit on the crop of cabbage = $ 1197 -870 = $327 OR $327 ÷ 1½ = $218 per. acres.

* transplant.

AFTER REAP ASSESSMENTS.

Importance of assessing

After reaping a crop, the vegetable grower should look at its overall performance. This is important as the grower should know:-

1. If it is profitable to continue growing the crop. or;

2. If another crop could not be grown at increased profits over the same period or in a shorter time. and;

3. If the crop reaped has proven suitable how practices can be improved to increase returns whether from:-
   - increasing sales at approx. the same costs.
   - reducing costs at approx the same sales.
   - increasing sales and costs, but ensuring that the increase in sales is greater than the increase in expenses.

How to make assessments.

After reap assessments should be done in stages viz.

1. C.O.P records in addition to the S.O.P records and notes for the crop should first be closely studied.

2. The records from the crop should then be compared with the records from other crops recently reaped. It is best not only to compare sales, costs and profits, but expenses should also be checked point by point. eg. labour cost for one crop vs cost for the other.

LIST OF MAIN REFERENCES

Part 2. (In addition to those used in Part I)

1. "Soil Technical Guide Sheets"
by Agricultural Chemistry Division of the Ministry of Agriculture (Jamaica)

2. "The Farmers Guide"
by The Jamaica Agricultural Society.

3. "Remote Areas Development Manual"
by American A.I.D.

4. "A Guide to Fertilizer Use on Vegetable Crops in the Commonwealth Caribbean"
by C.A.R.D.I.

5. "Agricultural Chemicals"
by Rohm and Haas (1964 &1965

6. "Handbook for Vegetable Growers
by J. Knott

7. *Commercial Vegetable Growing
by H. Tindall

8. *Vegetable Gardening in the Caribbean
by U.S.D.A.

9. * Weed-killers for Caribbean Agriculture
by Kasasian & Seeyave.

(Irrigation on Western Farms
by USDA Bulletin No.199.

ABC OF VEGETABLE FARMING

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v.II TEXTBOOK

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